Human Nature:

Agricultural Biodiversity *and* FARM-BASED FOOD SECURITY

by Hope Shand

An Independant Study prepared by the Rural Advancement Foundation International for the Food and Agriculture Organization of the United Nations.

RAFI

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HUMAN NATURE: AGRICULTURAL BIODIVERSITY AND FARM-BASED FOOD SECURITY

human nature: HUMAN NATURE:

agricultural AGRICULTURAL

biodiversity BIODIVERSITY

and farm-based AND FARM-BASED

food security FOOD SECURITY

RAFI
Rural Advancement Foundation International

A MESSAGE FROM FAO

Biodiversity – a technical concept as much as a 'green philosophy'– is here to stay. Since well before the Rio Earth Summit, we have become aware of the fragility of the genetic resources and ecosystems that provide the basis for our livelihood. Food and other agricultural products depend directly on germplasm incorporated in useful plants and animals, but also indirectly through the manifold functions that natural and managed ecosystems perform: buffering water and soil nutrients, stabilising erosion, controlling the invasion of harmful species and many others. This will be even more true in the world of tomorrow with its expected 10 billion inhabitants.

Yet, in the past, agriculture and nature conservation have often been seen to be in opposition. Agriculture was considered a threat to nature and vice versa; naturalists were seen as lobbying against agricultural production. Today, there is growing recognition that food security and the conservation and sustainable utilisation of agricultural biological diversity are inextricably linked. Even if we are only just beginning to understand their technical and social complexities, no one can deny the importance of domesticated diversity, as it is sometimes called.

The publication of this volume by the Rural Advancement Foundation International (RAFI) is, therefore, very welcome. It synthesises the rich technical literature on the subject of biological diversity as it relates to food and agriculture. While it draws on many sources, FAO is particularly pleased to have been closely associated by furnishing the authors with extensive technical documentation. The book addresses both the causes and potential consequences of biodiversity loss for food security, drawing out the implications for policy-making at national, regional and international levels.

Biological diversity for food and agriculture has always been central to FAO's mandate to promote sustainable agricultural development to ensure global food security. Mainstreaming biodiversity into national agricultural policies, programmes and projects constitutes a top priority. FAO's Commission on Genetic Resources for Food and Agriculture contributes to this goal by providing a neutral forum where Member States can meet to discuss and formulate policy in this area. Our sectoral programmes generate and transfer the information and technical know-how farmers need to conserve, develop and deploy biodiversity in sustainable and ecologically sound agricultural production systems.

Biodiversity issues are technically complex, sometimes politically controversial, and rarely susceptible to easy solutions. FAO, in supporting the study upon which this book is based, takes no position on these issues. The book reflects the thinking of RAFI and its authors and does not necessarily represent the views of the Organization or its Members States. RAFI is to be congratulated for tackling this very difficult subject, raising public awareness, and giving future debates on this subject the benefit of a diversity of views.

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A MESSAGE FROM RAFI

RAFI

The ever-growing flow of humanity off the farms and into the cities means that a growing percentage of the world's population is increasingly remote from the biological realities beyond the urban skyline. The gap between nature and human nature is widening. Because we are increasingly alienated from nature, we tend to underrate our dependence on a thriving ecosystem. We underestimate the implications of its erosion and we undervalue the critical place flora and fauna have in our own security.

Nowhere is the rift between nature and human nature more disturbing than with agricultural biodiversity. If recent UN conferences and the campaigns of civil society organisations have succeeded in drawing some public and political attention to biological diversity – at least the so-called "wild" elements of nature – much less attention has been paid to the plight of more domesticated diversity – including the crops, livestock, forests and fish – that feed, clothe, shelter, and protect us. The most immediately vital elements of biodiversity – the parts we are using directly everyday and will need even more tomorrow – are severely threatened. The loss of agricultural biodiversity doesn't mean unplugging the television set – it means unplugging the refrigerator.

RAFI has been dealing with biodiversity for twenty years. The UN Food and Agriculture Organization (FAO) has a much longer history. In the past two decades, RAFI has often been highly-critical of intergovernmental policies and programmes, especially those related to food crops, developed in FAO fora. Governments have moved too slowly. Intergovernmental meetings have tried too often to sidestep the tough political and economic realities that come with the genetic materials essential to food security. Despite years of often acrimonious debate and even passionate disagreement, RAFI has always made the distinction between intergovernmental negotiation and the place of FAO as the UN System's leader in addressing food and agricultural matters. FAO has played – and must continue to play – its central role in both protecting and developing agricultural diversity in the decades ahead. We must also acknowledge – even as we criticize some of its food or forest programmes – that FAO has been a pioneer – sometimes a creative and heroic pioneer – in the thankless struggle for food security through diversity. RAFI will continue to monitor intergovernmental activities and FAO programmes closely in the years ahead.

Written by Hope Shand
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Rural Advancement Foundation International

The Rural Advancement Foundation International is an international, non-governmental organisation headquartered in Ottawa, Ontario (Canada) with an affiliate office in Pittsboro, North Carolina (US). RAFI is dedicated to the conservation and sustainable improvement of agricultural biodiversity, and to the socially responsible development of technologies useful to rural societies. RAFI is concerned about the loss of genetic diversity – especially in agriculture – and about the impact of intellectual property rights on agriculture and world food security.

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LIST OF ACRONYMS

ALBC	American Livestock Breed Conservancy
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIFOR	Centre for International Forestry Research
CSD	United Nations Commission on Sustainable Development
FAO	United Nations Food and Agriculture Organization
FSC	Forest Stewardship Council
GATT	General Agreement on Tariffs and Trade
GRFA	Genetic Resources for Food and Agriculture
ICLARM	International Centre for Living Aquatic Resources Management
ICRAF	International Centre for Research in Agroforestry
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
INGA	International Network on Genetics in Agriculture
IPF	Intergovernmental Panel on Forests
IPGRI	International Plant Genetic Resources Institute
IRRI	International Rice Research Institute
ITTA	International Tropical Timber Agreement
ITTO	International Tropical Timber Organization
NGO	Nongovernmental Organization
PGR	Plant Genetic Resources
PGRFA	Plant Genetic Resources for Food and Agriculture
RAFI	Rural Advancement Foundation International
TFAP	Tropical Forest Action Plan
TRIPS	Trade Related Aspects of Intellectual Property Rights
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
WFP	World Food Programme
WWF	World Wildlife Fund

PART I: Biodiversity and People

It is human nature that rules the world,

not governments and regimes.

– Svetlana Alliluyewa[1]

CHAPTER 1

BIOLOGICAL MELTDOWN:

THE LOSS OF AGRICULTURAL BIODIVERSITY AND EROSION OF CULTURAL DIVERSITY

Introduction

During the Rio Earth Summit of 1992, the world began to understand the catastrophe unfolding in the destruction of biological diversity. For the first time, many of us became aware of species extinction and the collapse of ecosystems. The adoption of the Convention on Biological Diversity, at Rio, was a critically important first step in a global campaign to safeguard endangered diversity. Less discussed in the world media, but no less vital or urgent, is the devastation occurring in one unglamorous part of biodiversity – the part that feeds us.

Agricultural biodiversity refers to that part of biodiversity *that feeds and nurtures people* – whether it is derived from the genetic resources of plants, animals, fish or forests. We are losing genetic resources for food and agriculture at an unprecedented rate. It can best be described as a biological meltdown. What's at stake is nothing less than the biological basis for world food security. The statistics are numbing:

- Crop genetic resources are disappearing at the rate of 1–2% per annum.[2] Since the beginning of this century, about 75% of the genetic diversity of agricultural crops might have been lost.
- Domestic livestock breeds are disappearing at an annual rate of 5%, or 6 breeds per month.[3]
- Tropical forests are falling at a rate of just under 1% per annum, or 29 hectares per minute.[4] From 1980–1990, this is equivalent to an area the size of Ecuador and Peru combined.
- Marine fisheries are collapsing. All of the world's main fishing grounds are being fished at or beyond their limits. About 70% of the world's conventional marine species are fully exploited, overexploited, depleted or in the process of recovering from overfishing.[5] One-fifth of all freshwater fish are already extinct or endangered.[6]
- Soil – the critical life-support surface upon which we all depend – is eroding at a rate 13 to 80 times faster than it is being formed.[7]

Whether in farmer's fields, forests, fisheries, or in high-tech gene banks, the genetic variation needed to sustain agricultural systems is slipping into oblivion. Equally alarming, genetic resources are being privatized and their natural habitats plundered. Decline in diversity threatens the health of our planet and diminishes the quality of life everywhere. We are losing the biological options we need to strengthen food security and to survive global climate change. The consequences warns the United Nations Food and Agriculture Organization (FAO), are "serious, irreversible and global."[8]

CIDA PHOTO: ROGER LEMOYNE

Erosion of Cultural Diversity

It is a commonly accepted maxim that we are living in the "information age" and that we are generators of vast knowledge. After all, corporations and governments (primarily in the North) are mapping the genomes of pigs, bacteria and human beings. Scientists are tinkering with genes that control everything from human obesity to the colour of cotton. Biologists are cloning sheep, engineering bananas to contain human vaccines and expressing human proteins in cow's milk. From this perspective, the frontiers of human knowledge have never seemed so boundless.

Given these spectacular achievements, it is startling (and disconcerting) to learn that we may be the first generation in history to be losing more knowledge than we are acquiring. Perhaps the most shocking toll on biodiversity today is the erosion of the culturally-based knowledge represented by thousands of diverse cultures that are themselves endangered or disappearing.

Genetic resources for food and agriculture are unique because they have co-evolved in partnership and inter-dependence with human cultures. Countless different and genetically distinct plants and animals owe their existence to thousands of years of evolution and careful selection and nurturing by our farming ancestors. The erosion of cultural diversity is intricately linked to the loss of agricultural biodiversity:

- Linguists who monitor the status of surviving languages predict that approximately half of the 6,000 languages spoken in the world today will die during the 21st century.[9] It is no accident that the highest levels of plant and animal diversity, as well as the world's richest linguistic life, are found close to the Equator.[10] As each language vanishes, tens of thousands of years of cultural heritage and traditional knowledge are lost. Farming and indigenous communities are not only custodians of diversity, they are carriers of unique knowledge about agricultural biodiversity and entire ecosystems.
- Urban population is growing faster than world population, and experts predict that "the growth of cities will be the single largest influence on development" in the first half of the 21st century.[11] Within 10 years, more than half of the world's population will be living in cities. By 2025, four out of five urban dwellers will live in the South. Migration from rural areas accounts for approximately 40% of urban increase. While some skills and knowledge will be transferred and adapted to urban areas, the loss of farming communities and their accumulated knowledge of food production and ecosystems is inevitable.

The loss of traditional farm communities, languages, and indigenous cultures, all represent the erosion of human intellectual capital on a massive scale. The loss of traditional knowledge is tantamount to losing a road map for survival – the key to food security, environmental stability and improving the human condition.

Why this Booklet? Bringing the Pieces Together

In recent years considerable progress has been made in understanding the value of genetic resources for food and agriculture, and in creating inter-governmental frameworks for conserving, using and developing plant and animal germplasm both equitably and sustainably. The origin of the intergovernmental activity is traceable to the earliest days of the UN's Food and Agriculture Organization (FAO) in the mid-Forties. Scientific panels began monitoring genetic resources shortly after FAO was founded and continued their work throughout the following decades. But, agricultural biodiversity is not just a technical and environmental issue – it is a profoundly political one. By the late Seventies, governments at FAO recognized this sometimes uncomfortable reality and debates began then that led to the creation of the FAO Commission on Plant Genetic Resources in 1983. Despite this and decades of intensive scientific and policy work by other multilateral actors including the UN Environment Programme (UNEP), the UN Educational, Scientific and Cultural Organization (UNESCO), the Consultative Group on International Agricultural Research

(CGIAR) and, most significantly, the UNCED Agenda 21 and the Biodiversity Convention itself, many of the central policy questions remain unanswered.

Now, fifty years after the international community recognized the importance of agricultural diversity, the outstanding issues are moving toward the centre of political debate. A series of intergovernmental meetings in 1996 and 1997, including the Leipzig Conference on Plant Genetic Resources (June, 1996), FAO's World Food Summit (November, 1996), future meetings of the Biodiversity Convention and the UN Commission on Sustainable Development and the General Assembly review of Agenda 21, all offer critical opportunities to further define and implement programmes for managing and using agricultural biodiversity as the foundation of global food security. The opportunity is at hand to turn plans into practice and awareness into action, and to make farm-based food security the centrepiece.

This booklet provides an introduction to the topic of agricultural biodiversity, followed by brief chapters assessing the current situation for each major sector: crop genetic resources, farm animal diversity, fish and aquatic life, forests, soil biodiversity and microbial genetic resources. It concludes with a discussion of outstanding policy issues that must be addressed by policymakers and global civil society on the eve of the new millennium.

CIDA PHOTO: PETER BENNETT

Several common themes emerge from our analysis of the plant and animal genetic resources that feed, nurture and sustain life:

1. It is impossible to talk about the conservation and sustainable use of genes, species and ecosystems separate from human cultures. The knowledge of indigenous peoples and rural communities is the cornerstone of global food security and human health, and is the building block for environmental security.[12] Indeed, the development of sustainable agriculture systems depends upon the innovative capacity of millions of farmers, forest dwellers, pastoralists and fisherfolk, and their accumulated knowledge of biological resources.

If we are to conserve genetic resources for future generations, then we must be concerned not simply with "rescuing" genetic materials from tropical centres of diversity, but also with recognizing, rewarding and protecting the traditional knowledge systems that have produced and maintained these biological riches. Ultimately, we cannot conserve the world's biological diversity unless we also nurture the human diversity that protects and develops it. If we undervalue or ignore the traditional knowledge of farmers and rural people who use and manage biodiversity as the basis for their livelihoods, we lose our last, best hope for salvaging and developing the living resources upon which we all depend.

2. Farming and indigenous communities hold the key to conservation and use of agricultural biodiversity, and to food security for millions of the world's poor. The world's main food and livestock species have their centres of genetic diversity in the South. Generations of farmers/breeders in the tropics and sub-tropics and the drylands have consciously selected and improved plants and animals that are uniquely adapted to thousands of micro-environments. Today, farming communities in Africa, Asia and Latin America are the primary custodians of most of the earth's remaining agricultural genetic resources. Whether used by farmers, institutional breeders or genetic engineers, the South's plant and animal diversity represents the first and most essential resource for sustaining and improving agriculture.

Though frequently characterized as "resource poor," many of the South's farming communities are extraordinarily rich in plant and animal genetic diversity and in traditional knowledge. But these are endangered resources. With the drive for export monoculture and the spread of Green Revolution technology in the South, the dominant model for agricultural production has been based on *external* inputs – imported germplasm, technology and the intellectual capabilities of outside "experts." Ironically, the Green Revolution approach (high-input, high-tech, and high-yielding crop and livestock breeds) has proved so successful that it has very nearly extinguished many of the farming communities and their most vital "internal" resources – farmers' traditional knowledge and the rich reservoirs of plant and animal genetic diversity that they have selected and improved for generations. The erosion of traditional knowledge and agricultural genetic resources not only marginalizes the South's food producers and farming communities, it jeopardizes world food security.

The search for sustainable food security must begin where the food is harvested and with the people who do the harvesting – whether forest dwellers, farmers, pastoralists, or fisherfolk. They are the innovators best situated to develop new technologies, germplasm, and management systems for their diverse ecosystems. Rather than emphasize the need for external inputs, sustainable food security requires that we build on the "internal resources" of rural communities. The needs and capabilities of those with the greatest stake in conserving and using agricultural biodiversity – farming communities – must become the centrepiece of policies to address food insecurity. The challenge for the world community is to link conservation and development by enabling farm communities to assume a major role in managing and benefiting from the genetic resources on which their livelihoods depend.

3. Successful strategies to secure the earth's diminishing stock of plant and animal genetic resources require integrated approaches that combine the genius of farming communities with the institutional sector's scientific innovation. Global food security is only as good as the genetic base we conserve and use, and that depends, quite literally, on the innovation, skills and knowledge of millions of agricultural innovators who nurture biodiversity on a daily basis.

Although agricultural genetic diversity is concentrated in the South, no country or region is "self-sufficient" in plant or animal genetic resources. Genetic inter-dependence among all nations underscores the need for international cooperation in conserving and using biodiversity. Successful strategies will require *integrated* approaches that build upon the knowledge and innovation of farming communities while also drawing on formal sector science and technology.

4. With renewed emphasis on global food security, a new, holistic approach is needed to address the loss of genetic resources for food and agriculture. In the past, governmental bodies and multilateral institutions have approached policy on agricultural biodiversity in a piecemeal, fragmented fashion. The Western, technocratic approach often has spawned

the establishment of numerous technical and political bodies to specialize in different sectors of food and agriculture – plants, fish, forests, or livestock – with little coordination and few unified strategies between them. Some have called it a monoculture approach to diversity.

We would do well to take our cue from farmers. A salient feature of traditional farming systems is diversity and the utilization of a wide range of plants, animals and trees – both wild and domesticated – from both terrestrial and aquatic habitats. Food and livelihood security for the rural poor depends on complex interactions between plants and animals. Addressing food security requires that policymakers and institutions take a more integrated and holistic approach to farming systems. In the future, agricultural biodiversity must be approached as a dynamic whole, rather than as a collection of independent sectors.

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OVERVIEW

Agricultural biodiversity: Why is it so important?

Biodiversity provides not only the food that nourishes people, but countless raw materials and services such as fiber for clothing, material for shelter, transport, draught, fertilizer, fuel and medicines. Today, millions of farmers, herders, forest dwellers and fisherfolk, especially in the South, are the primary innovators and stewards of this legacy. The rural poor depend upon biological resources for an estimated 90 percent of their survival requirements.

The industrialized world depends on access to biological resources for a vast array of industrial products, and as sources for pharmaceuticals. In agriculture, the raw material for both plant and animal breeding as well as new biotechnologies are the genes contained in plants and animals found primarily in the South.

In addition to the tangible benefits of food, services, and raw materials derived from biological resources, biodiversity functions as a life-support system for the planet. Biodiversity contributes to the oxygen we breathe and helps maintain atmospheric quality; it regulates and stabilizes climatic conditions, maintains water supply and quality; generates and maintains topsoil; converts solar energy and nutrients into plant matter; breaks down organic wastes and recycles nutrients; controls pests and diseases.

Distribution of higher plants (including ferns, cycads, conifers and broad leaved species) by region and sub-region[1]

Latin America		*85,000*
Africa		*45,000–40,000*
	North Africa	*10,000*
	Tropical Africa	*21,000*
	Southern Africa	*21,000*
Tropical and subtropical Asia		*50,000*
	India	*15,000*
	Insular Asia	*30,000*
	China	*30,000*
Australia		*15,000*
Mediterranean basin		*25,000*
North America		*17,000*
Europe		*12,500*
World		***270,000***

SOURCE: *Global Biodiversity – WCMC (1992)*

1 As subregions may have common species, the numbers cannot be added to make regional totals.

Underlying Causes

Biodiversity is threatened at all levels; we are losing genes within species, species within ecosystems, and ecosystems within regions. Human destruction of natural habitats, whether exploited for commercial or subsistence reasons, is the greatest threat to biodiversity. The clearing of land for agriculture, over-grazing of grasslands, cutting and burning of forests, logging, fuelwood collection, indiscriminate use of pesticides, over-exploitation of fisheries, draining and filling of wetlands, urbanization, pollution of air and water, the devastating impacts of war and natural disasters – these are just a few examples. Neither terrestrial nor aquatic habitats are immune to the ravages of human-induced destruction.

Loss of biodiversity is frequently characterized as an environmental problem, but the underlying causes are social, economic and political. The excessive and unsustainable consumption of resources by a small but rich minority of the world's population, coupled with the destructive impacts of the world's poor in a desperate bid for survival, have altered, over-exploited or destroyed natural habitats worldwide. While the pressures of human population growth are real and undeniable, it is by no means clear whether over-consumption or poverty ultimately leads to greater loss of biodiversity.[13] Growing disparity between rich and poor promotes unsustainable human activities that deplete the earth's biotic wealth. Over the past 30 years, the poorest 20% of the world's people saw their share of global income shrink from 2.3% to 1.4%. Meanwhile, the share of the richest 20% of the world's population rose from 70.2% to 82.7%.[14] In more graphic terms, the assets of the world's 358 billionaires exceed the combined annual incomes of countries with 45% of the world's people.[15] Inequities within nations drive the destruction of biological resources no less than those among nations. UNEP's Global Biodiversity Assessment observes, "In most countries, ownership and control of land and biotic resources, and all the benefits they confer, are distributed in ways that work against biodiversity conservation and sustainable living."[16]

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.[17]

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 the average rate of breed loss could be about three breeds every two weeks.[18]
- 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.[19]

Why are Agricultural Genetic Resources Important?

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.

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 metres. Each 1 degree rise in temperature will displace the tolerance of terrestrial species some 125 km. towards the poles, or 150 metres in altitude.[20] 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.[21] But since climate will be changing faster than the migration rate of most species, experts predict a "drastic reduction" in global species diversity.[22]

If we are to adapt food production systems to radically changing conditions in the coming decades, plant and animal genetic diversity will be the single most critical resource for doing so. Agricultural genetic resources thus hold the key to increasing food security, environmental stability, and improving the human condition.

Where is Diversity Found?

Genetic diversity is important wherever it is found, but not all nations are equally endowed. In general, a small number of countries lying within the tropics and subtropics account for a very high percentage of the world's biodiversity.[23] It is well known that all major food crops, the staple crops grown and consumed by the vast majority of the world's population, have their origins and centres of diversity in the tropics and subtropics. By and large, other forms of animal and plant genetic diversity are also heavily concentrated in the South. The following are just a few examples:

- There may be more plant species in the area covered by Botswana, Lesotho, Namibia, South Africa and Swaziland, than in any other region of the world of comparable size.[24]
- Most domesticated animals have their centres of origin in the South; North America and Oceania have no indigenous mammalian livestock species.[25] Domestic animal diversity is perhaps greatest in the South, although data on non-European indigenous breeds is shockingly incomplete.[26]
- Species richness of the deep ocean rivals that of tropical rain forests. New research reveals that the diversity of species at the bottom of the ocean is richest in the tropics and diminishes as one moves toward either pole.[27]
- Covering over 600,000 sq. km, coral reefs contain more species per unit than any other marine ecosystem; over half this area is in the Indo-Western Pacific and about 15% is in the tropical Atlantic.[28]
- Tropical Lake Malawi has 245 species of fish, while Lake Windermere (UK) has only nine. Brazil claims more than 3,000 freshwater fish species, three times more than any other country.[29]
- The Indo-West Pacific Ocean contains an estimated 1,500 species of fishes and over 6,000 mollusc species, compared to only 280 fish and 500 mollusc species in the Eastern Atlantic.[30]
- Indonesia ranks first, second, sixth and eighth in the number of species of endemic birds, mammals, reptiles and amphibians respectively. In contrast, Britain has few or no endemic species in any of these four groups.[31]
- Tropical forests contain at least one-half of all known plant and animal species. In Malaysia, an area of forest covering just 50 hectares was found to contain 830 tree species. By contrast, there are 50 indigenous tree species in Europe north of the Alps.[32]

Genetic Inter-dependence

All nations are inter-dependent in terms of access to biological resources. The richest nations on earth are home to the smallest pockets of genetic diversity, while some of the poorest nations are stewards of the very richest reservoirs. Although agricultural genetic diversity is concentrated in the South, no country or region is "self-sufficient" in plant or animal genetic resources. Even the most genetically abundant regions of the world look beyond their own borders for at least half of the germplasm required for their staple foods. In Brazil, for example, a "megacentre" of biodiversity, half of the population's energy from plants comes from rice, wheat and maize – all of which originated elsewhere.[33] Sugar, which provides one-fifth of energy intake in Brazil, originated in Southeast Asia. Cassava (supplier of 7% of energy intake) is the only major food source originating in Brazil. For industrialized regions dependency on "imported" germplasm often exceeds 95 percent.

Given the importance of agricultural genetic diversity, it's not surprising that there has been enormous debate in the last 15 years over the control and ownership of biological resources. Fortunately, there is growing appreciation for the fact that all nations on earth are genetically *interdependent.* This reality underscores the need for international cooperation in conserving and using these materials, and in recognizing the vital role of rural communities who nurture and manage genetic resources for food and agriculture.

Notes

1 Quoted in *New York Times*, November 3, 1984.

2 United Nations Food and Agriculture Organisation (FAO), "Plant Genetic Resources", *Development Education Exchange Papers* (DEEP), September, 1993, p. 3.

3 FAO Press Release. "New FAO World Watch List for Domestic Animal Diversity Warns: Up to 1,500 Breeds Are at Risk of Extinction," 5 December 1995.

4 Estimate of 29 hectares per minute comes from Consutative Group on International Agricultural Research (CGIAR) press release, "Poor Farmers Could Destroy Half of Remaining Tropical Forest," 4 August 1996.

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6 Heywood, V.H., Executive Editor. *Global Biodiversity Assessment*, Published for the United Nations Environment Programme by Cambridge University Press, 1995, p. 965.

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8 FAO. *State of the World's Plant Genetic Resources for Food and Agriculture*, Rome, 1996, p. 25.

9 Wheeler, David L. "The Death of Languages," *The Chronicle of Higher Education*, 20 April 1994.

10 Popham, Peter. "The Day a Language Died," *World Press Review*, v. 43, n.4 (April 1996), p. 38.

11 United Nations Population Fund, *The State of the World's Population*, 1996, p. 1.

12 Mooney, Pat. "Farmer-Led Food Security: Community Genius and the Integration of Food, Health, Environment and Knowledge Security", *Development Dialogue*, (in press).

13 Global Biodiversity Assessment, p. 782.

14 United Nations Development Programme (UNDP). *Human Development Report*, Oxford University Press, New York, 1996. p.2.

15 *Human Development Report*, p. 2.

16 *Global Biodiversity Assessment*, p. 782.

17 National Research Council, *Managing Global Genetic Resources*, National Academy Press, Washington, 1993, p. 76.

18 FAO Press Release, 5 December 1995.

19 *Global Biodiversity Assessment*, p. 746.

20 *Global Biodiversity Assessment*, p. 763.

21 *Global Biodiversity Assessment*, p. 321.

22 *Global Biodiversity Assessment*, p. 321.

23 *Global Biodiversity Assessment* cautions that "*there can be no shortcuts in understanding the patterns of diversity.*" (p. 90). However, tropics are generally richer is species diversity than temperate habitats. It is important to keep in mind that biodiversity within an area can be characterized by measures of species richness, species diversity, taxic diversity, and functional diversity – each highlighting different perspectives.

24 FAO, "Plant Genetic Resources", p. 4.

25 Mason, Ian L. and Roy D. Crawford, "Global Status of Livestock and Poultry Species," Appendix A, in *Global Genetic Resources: Livestock*, National Research Council, Washington, p. 143.

26 Hall, Stephen J.G. and John Ruane, "Livestock Breeds and Their Conservation: A Global Overview," *Conservation Biology*, Vol. 7, No. 4 (December 1993), p.815. This article concludes that breed biodiversity varies markedly between continents, but data are particularly lacking from the developing world. In Africa, numbers of breeds are correlated with human population and with land area.

27 *Diversity*, Vol. 9 No. 4 (1993) and Vol. 10, No. 1 (1994), p. 83.

28 *Global Biodiversity Assessment*, p. 381.

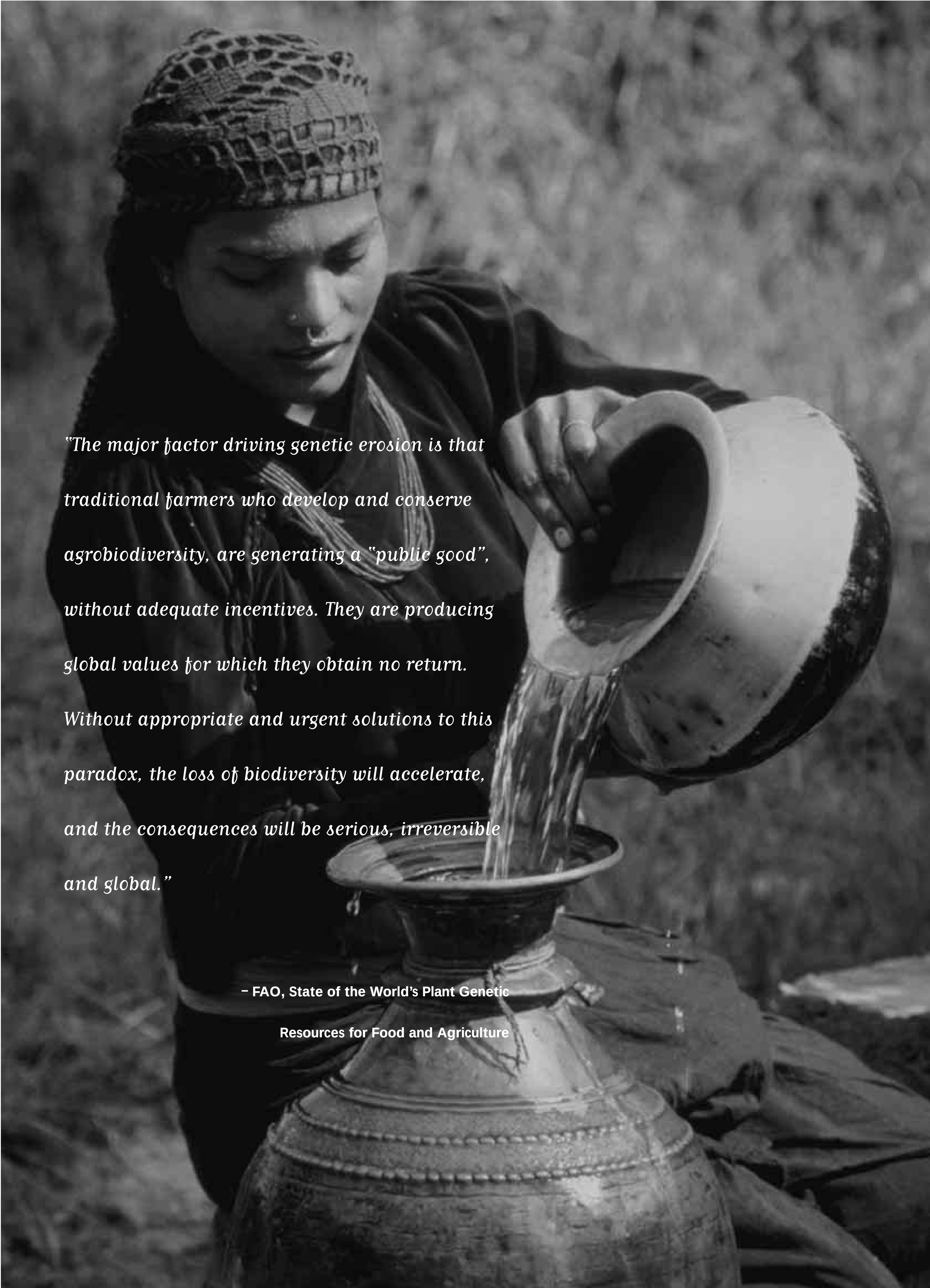
29 *Conserving the World's Biological Diversity*, p. 92, box 20.

30 World Resources Institute (WRI) et al. *Global Biodiversity Strategy*, 1992, p. 9.

31 *Global Biodiversity Assessment*, p. 90.

32 FAO. *State of the World's Forests*, Rome, 1995, p. 21.

33 This example is from FAO, *The State of the World's Plant Genetic Resources for Food and Agriculture*, (Background Documentation prepared for the Fourth International Technical Conference on Plant Genetic Resources, Leipzig, Germany, 17-[23] June 1996), p. 14.



"The major factor driving genetic erosion is that traditional farmers who develop and conserve agrobiodiversity, are generating a "public good", without adequate incentives. They are producing global values for which they obtain no return. Without appropriate and urgent solutions to this paradox, the loss of biodiversity will accelerate, and the consequences will be serious, irreversible and global."

– FAO, State of the World's Plant Genetic Resources for Food and Agriculture

CHAPTER 2

PEOPLE, INNOVATION AND AGRICULTURAL BIODIVERSITY

Introduction

Biodiversity without people is a very incomplete picture. Contrary to western urban mythology, a field of wheat, a flock of sheep grazing, or even a pristine tropical forest are far from being "natural" landscapes. There's no denying that the earth's biotic wealth is the product of hundreds of millions of years of evolutionary history. But to an astonishing degree, agricultural genetic resources owe their existence to human influence and manipulation.

Today, humans manipulate approximately 70% of the world's temperate and tropical ecosystems to produce 98% of their food and all of their wood products.[34] Only 5% of the earth's temperate and tropical land area is totally uninhabited and unmanaged.[35] Even coastal and marine biodiversity is found predominantly in areas where fishing and other human activities take place.[36] Living diversity in nature corresponds to and depends upon a diversity of human cultures.

The past and future of agricultural biodiversity is inextricably linked to millions of farmers, herbalists, herders, and fisherfolk worldwide. People from thousands of human cultures have adapted to diverse habitats, and they have used, altered, and nurtured biodiversity to meet countless human needs.

For centuries, rural people have practised and relied upon the sustainable use of biodiversity as the basis for their livelihoods. The indigenous knowledge of thousands of human cultures is of utmost importance in understanding, utilizing, and conserving biodiversity for sustainable development.

Farmers as Innovators and Conservers of Diversity

Farmers have managed genetic resources for as long as they have cultivated crops. For over 10,000 years they have selected and improved traditional varieties and livestock breeds to meet specific conditions of their agro-ecological environments and diverse nutritional and social needs. The immense genetic diversity of traditional farming systems is the product of human innovation and experimentation – both historic and ongoing. Indigenous farmers of the Andes, for instance, maintain a gene pool of some 3000 varieties of potatoes representing eight species.[37] In Papua New Guinea, as many as 5000 varieties of sweet potatoes are under cultivation, with as many as 20 varieties being planted in a single garden.[38]

Traditional Maori weavers of Aotearoa/New Zealand recognize over 80 genetically and geographically distinct forms of local flax (*Phormium cookianum* and *P. tenax*).[39] In Java, small farmers cultivate 607 crop species in their home gardens, with an overall species diversity comparable to a deciduous tropical forest.[40] Traditional pastoralists have selected and maintained hardy livestock breeds that are capable of thriving in extreme environments such as deserts; at least a dozen breeds of camel are known in the Sudan alone.[41]

CIDA PHOTO: PAT MORROW

The "Hidden" Harvest: Food Security and Wild Genetic Resources

It is only in recent years that Western observers have begun to understand the value and importance of *wild* resources to people's livelihoods. The extent to which local people use food harvested from wild species is typically hidden to outsiders, and thus the role of farmers and rural people (especially women) in maintaining and conserving wild plants and animals is seldom recognized. In their groundbreaking work on this subject, researchers Ian Sconnes, Mary Melnyk and Jules Pretty refer to wild resources – all non-domesticated plant and animal species which are used by people – as "the hidden harvest."[42]

In many parts of the world, wild species and natural habitats are managed and used on a daily basis for household food security. Wild resources are collected to improve diets, to tide people over in times of famine, to supplement income, to provide genetic material for experimentation, as a source of medicines, food, utensils, craft and building materials.[43] Many wild areas also have significant cultural or spiritual importance. Depending on the context and season, between a fifth and a half of all foods consumed by the poor is not cultivated but harvested from forests, un-tilled fields, or streams.[44] In two districts of West Bengal, 124 "weed" species collected from rice fields were found to possess local economic importance to farmers and their families.[45] In the Uxpanapa region of Veracruz, Mexico, peasant farmers utilize 435 wild plant and animal species, of which 229 are eaten.[46] In one Tanzanian village over 80% of the vegetable side dishes were composed of wild plants.[47] The agropastoral people of Tswana use 126 plant species and 100 animal species as sources of food.[48]

New research on the value of "wild" species reveals what millions of rural poor people have known and practised for millenia: There is no clear boundary between "domesticated" and "wild" species. The distinction between the fallow field and the cultivated may be illusory. Many species long considered to be "wild" are actively managed and improved by people. Food and livelihood security for the poor depends not just on cultivated crops and domestic livestock, but on non-cultivated foods and wild species. Ultimately, conservation of wild genetic resources depends on policies that acknowledge and support local people's rights to use, access and benefit from the genetic resources they have nurtured and developed.

Healing Nature: Biodiversity, Indigenous Knowledge and Health Security

Traditional medicines, although based on biological resources, are products of human knowledge that are of utmost importance to human health worldwide. Over 80% of the world's population relies on local health practitioners and traditional medicines for their primary medical needs.[49]

A Note on the Biodiversity Convention

Together with its sister conventions for Desertification and Climate Change, the Convention on Biological Diversity (CBD) has joined the multilateral community surrounded by high expectations. Despite the fanfare and furor of UNCED, however, the new Conventions arrive at a time when there is no new money and very little government enthusiasm for new UN institutions. Added to these serious constraints, the CBD, as a "cross-cutting" instrument intended to give focus to the UN's work in all fields of biodiversity, has little definable power to enforce its will. Civil Society Organizations less familiar with UN agencies find it difficult to realize that every intergovernmental body has the same weight and stature (technically) as every other organ. Thus, the CBD's Convention of the Parties (COP) does not stand above UNESCO or FAO. Nor is it pre-eminent over the World Trade Organization (WTO) even though it came into force before the WTO. In the end, power and influence over intergovernmental affairs is directly dependent upon the weight accorded to an agency by national governments and the world's media.

CIDA PHOTO: ROGER LEMOYNE

Between 35,000 and 70,000 species of higher plants are used directly as medicines.[50] Over 60 species of plants are used to treat skin infections in the Amazon region alone. Worldwide, at least 3,000 plants are used by indigenous peoples to control fertility. In Ghana, where the ratio of dentists to total population is only 1:150,000, some 27 woody species with anti-bacterial properties are used as chewing sticks, a popular and effective form of dental hygiene.[51] A study of ethnoveterinary practices in northwest Cameroon reveals that local people use nearly 400 medicinal plants to treat animal health problems.[52]

Traditional medicines and indigenous knowledge also have immense commercial value. An estimated three-quarters of all plant-derived prescription drugs were discovered because of their prior use in indigenous medicine. Globally, an estimated US$32,000 million per annum in pharmaceutical industry profits are drawn directly from traditional remedies.[53] Between the late 1950s and 1980, drugs derived from medicinal plants consistently accounted for not less than a quarter of all prescription drug sales in the United States.[54] When the overall benefits to society are taken into account, the value of plant-derived pharmaceuticals is astounding. It is estimated that the total economic value of plant-derived pharmaceuticals exceeds US$68,000 million annually in the US alone.[55]

A growing number of pharmaceutical corporations and biotechnology companies are stalking the forests, fields, and waters of the South in search of biological riches and indigenous knowledge. One bioprospecting company has had extraordinary success in searching

Thus, the CBD is the technical equal of the WTO – but only politically so if you believe that Ministers of Environment hold more sway than Ministers of Trade or of Finance. The CBD must use its prestige (as an Agenda 21 initiative) with its powers of persuasion to convince other UN agencies and national governments to abide by its decisions. Not an easy task.

There are already signs that the CBD's honeymoon is over. Environment and development NGOs are giving indications that they are becoming impatient with the high rhetoric and low level of action in the CBD. The CBD itself seems to be having difficulty defining its field of real action possibilities. At its best, the CBD is the "constitution" under which other UN agencies carry out their mandates related to biodiversity. The CBD monitors biodiversity and recommends work in areas of need. The CBD is – and should remain – the world's premier forum on biodiversity conservation.

At its worst, the CBD becomes an excuse for delay among other agencies and governments. Its hastily crafted text entrenches the conservation of all the *in situ* biodiversity that we do not know to exist and do not know to have value – while omitting from conservation all the *ex situ* biodiversity that we know to exist and know to have value.

It is vital that Civil Society Organizations not despair too quickly over the potential of the CBD. It has a tremendously important role to play. It must, however, learn to work effectively with its fellow multilateral institutions in order to do its work well.

for valuable medicinal compounds in tropical countries because they use indigenous knowledge as the basis for their plant collecting. More than half of the company's collected plant samples show promise as new drugs, as compared to less than 1 percent for conventional mass screening techniques.[56] A North American dental institute is studying anti-infective medicinal plants used by *curanderos* (healers) of the Kekchi Indians of Guatemala, the Paya of Honduras and other indigenous peoples of Central America.[57] It was a woman healer in Samoa who led a Western botanist to a tree, *Homolanthus nutans*, that she uses to treat viral illnesses. In laboratory tests, a chemical derived from the bark of the tree, known as prostratin, appears to protect immune cells from being destroyed by the HIV virus. In 1995, a US-based biotechnology company announced that it had identifed 32 extracts from traditional Chinese herbal medicines that hold significant potential for preventing the sexual transmission of AIDS.[58]

CIDA PHOTO: ROGER LEMOYNE

Caring Nature: Biodiversity, Indigenous Knowledge and Environmental Security

Traditional knowledge is increasingly important for the development of sustainable agricultural practises, and as a source for environmentally-sound innovations in many areas of science and industry. The following are just a few examples:

Endod, *Phytolacca dodecandra*, commonly known as the African soapberry, is a perennial plant that has been cultivated for centuries in many parts of Africa where its berries are traditionally used as a laundry soap and shampoo. Ethiopian biologist Aklilu Lemma, observed that downstream from where women were washing clothes with endod berries, dead snails were found floating in the water. Further research revealed that sun-dried and crushed endod berries are lethal to all major species of snails – but do not harm animals or people, and are completely biodegradable. Endod is now being developed as a low-cost, natural molluscicide for controlling schistosomiasis, a deadly disease transmitted by freshwater snails that infects more than 200 million people per annum. In addition to the use of endod to control the spread of schistosomiasis in tropical countries, research is now underway in the United States on the potential use of endod to control the infestation of zebra mussels in North American waters. The University of Toledo (USA) holds US patent no. 5,252,330 on the use of endod to control zebra mussels. This application of endod has an estimated market of US$10 million per annum in the US alone.[59]

For centuries, Indian farmers have used seeds from their native neem tree *(Azadirachta indica)* as a natural insecticide to protect their crops and stored grain. Drawing on traditional knowledge and local practices, Indian scientists isolated compounds from the oil, seeds, bark and leaves of the neem tree, which proved to be extremely effective against insects, even in minute quantities. Today, neem reportedly controls more than 200 species of insects, mites and nematodes, including major pests such as locusts, rice and maize borers, pulse beetles and rice weevils. Unlike most synthetic pesticides, insects have found it difficult to develop resistance to neem because it contains a number of biologically active ingredients which are harmless to birds, mammals and beneficial insects. Since 1985, more than 30 US patents have been issued to US and Japanese companies on formulas for neem-based solutions and emulsions for both insecticidal and medicinal uses.[60] Indian activist Vandana Shiva observes that, because of industry's increasing demand for neem seed, a traditional resource is now scarce or priced out of reach for many poor people.[61]

Thanks to indigenous farmers of Central America, an entire new industry is being developed in North America based on natural coloured cottons. A US plant breeder, has been awarded Plant Breeders' Rights for two varieties of naturally-coloured cottons ("coyote" and "green") that she developed using conventional plant breeding techniques. The naturally-coloured cotton seeds came from a US Department of Agriculture seed bank, and were originally collected in indigenous farming communities in Mexico or Central America. The natural coloured cottons do not require the chemical bleaching and dying processes that are environmentally harmful and typical of most industrial textiles.

"Inhuman" Nature: Intellectual Property Jeopardizes Informal Innovation and Biodiversity Conservation and Use

There is growing recognition worldwide that the innovation of farmers and indigenous peoples is of utmost importance in understanding, utilizing, and conserving biological diversity for agriculture, human health and the environment. The principle of "Farmers' Rights" – established by the United Nations' Food and Agriculture Organization (FAO) in 1989 – recognizes that farmers and their communites have contributed greatly to the creation, improvement and use of plant genetic resources and that they should be recognized and rewarded for past and ongoing contributions. The Convention on Biological Diversity, the first legally-binding framework for conservation and sustainable use of biodiversity, recognizes the "knowledge, innovations and practices of indigenous and local communities" and specifically "encourage[s] the equitable sharing of benefits arising from the utilization of such knowledge, innovations and practices" (Article 8(j)).

Unfortunately, international efforts to conserve biodiversity, use it equitably and sustainably, and to recognize and reward the contributions of farmers and indigenous peoples are jeopardized by conflicting trends in intellectual property. "Intellectual property rights" refers to a group of laws (patents, Plant Breeders' Rights, copyright, trademarks and trade secrets) which grant legal protection to individuals who create ideas or knowledge. Proponents of intellectual property for plants argue that patents and Plant Breeders' Rights promote innovation in plant breeding by rewarding "inventors" of new technologies, and thus enable companies to recoup their research investment.

The once-unthinkable idea that a gene, plant, animal, microorganism, and even human genetic material could become subject to exclusive monopoly control under intellectual property regimes is now standard practice in many industrialized nations, and is gaining ground in the rest of the world under the weight of legally-binding international agreements. Today, industrial patent laws and Plant Breeders' Rights legislation allow for exclusive monopoly control of virtually all biological products and processes that meet standard patent criteria (novelty, utility, non-obviousness).

While the Convention on Biological Diversity recognizes the importance of indigenous and local communities in conserving and making available knowledge and genetic resources, it also makes the dismaying concession that intellectual property rights will be "adequately and effectively" protected. The Uruguay Round of the General Agreement on Tariffs and Trade (GATT) incorporates an element called Trade Related Aspects of Intellectual Property (TRIPs) which obligates all signatory states to implement intellectual property provisions for plant varieties and microorganisms.

Sanctioned by the Biodiversity Convention and globally propelled by the World Trade Agreement, intellectual property laws give transnational corporations extraordinary economic control in new markets, allowing them not only to collect royalties, but to set conditions for the access and sale of a patented technology for up to 25 years. With the advent of genetic engineering, transnational enterprises in the industrialized world are staking far-reaching claims of ownership over a vast array of living organisms and biological processes that are used to make commercial products.

For farmers and consumers in the South, access to patented technologies means having to pay royalties on products that are based on their own biological resources and knowledge. Endod, neem and coloured cotton varieties, for example, are all subject to patents or Breeders' Rights in the industrialized world. But these patents neither recognize nor reward

CIDA PHOTO: DAVID BARBOUR

the innovations, knowledge and labour of traditional farmers and indigenous peoples. Who are the original "innovators", and who stands to profit? Pharmaceutical corporations profit handsomely from traditional knowledge and remedies, but profits have rarely, if ever, gone to the indigenous people who led researchers to them.

Existing legal frameworks are inadequate to protect the rights of farmers and indigenous peoples, and thus intellectual property laws constitute one of the greatest threats to the future conservation and enhancement of biodiversity. As industrial intellectual property regimes extend worldwide, monopoly control over biological products and processes jeopardizes world food security, undermines conservation of biological diversity, and threatens to further marginalize the world's poor.

Notes

34 *Global Biodiversity Assessment*, p. 943.

35 *Global Biodiversity Assessment*, p. 943.

36 *Global Biodiversity Assessment*, p. 943.

37 *Global Biodiversity Assessment*, p. 595.

38 *Global Biodiversity Assessment*, p. 724.

39 *Global Biodiversity Assessment*, p. 595.

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41 Kohler-Rollefson, Ilse. “Traditional Pastoralists as Guardians of Biological Diversity” *Indigenous Knowledge and Development Monitor*, Vol. 1, No. 3 (1993), p.15.

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43 ”The Hidden Harvest: The Value of Wild Resources in Agricultural Systems (A Summary)”, p. 5.

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46 UNDP. “Agroecology: Creating the Synergism for a Sustainable Agriculture,” in *UNDP Guidebook Series*, 1995, p. 8.

47 ”The Hidden Harvest: The Value of Wild Resources in Agricultural Systems (A Summary)”, p. 7.

48 ”The Hidden Harvest: The Value of Wild Resources in Agricultural Systems (A Summary)”, p. 6.

49 Inglis, Julian. “Traditional Health Systems,” *Nature and Resources*, Vol. 30, No. 2 (1994), p. 3.

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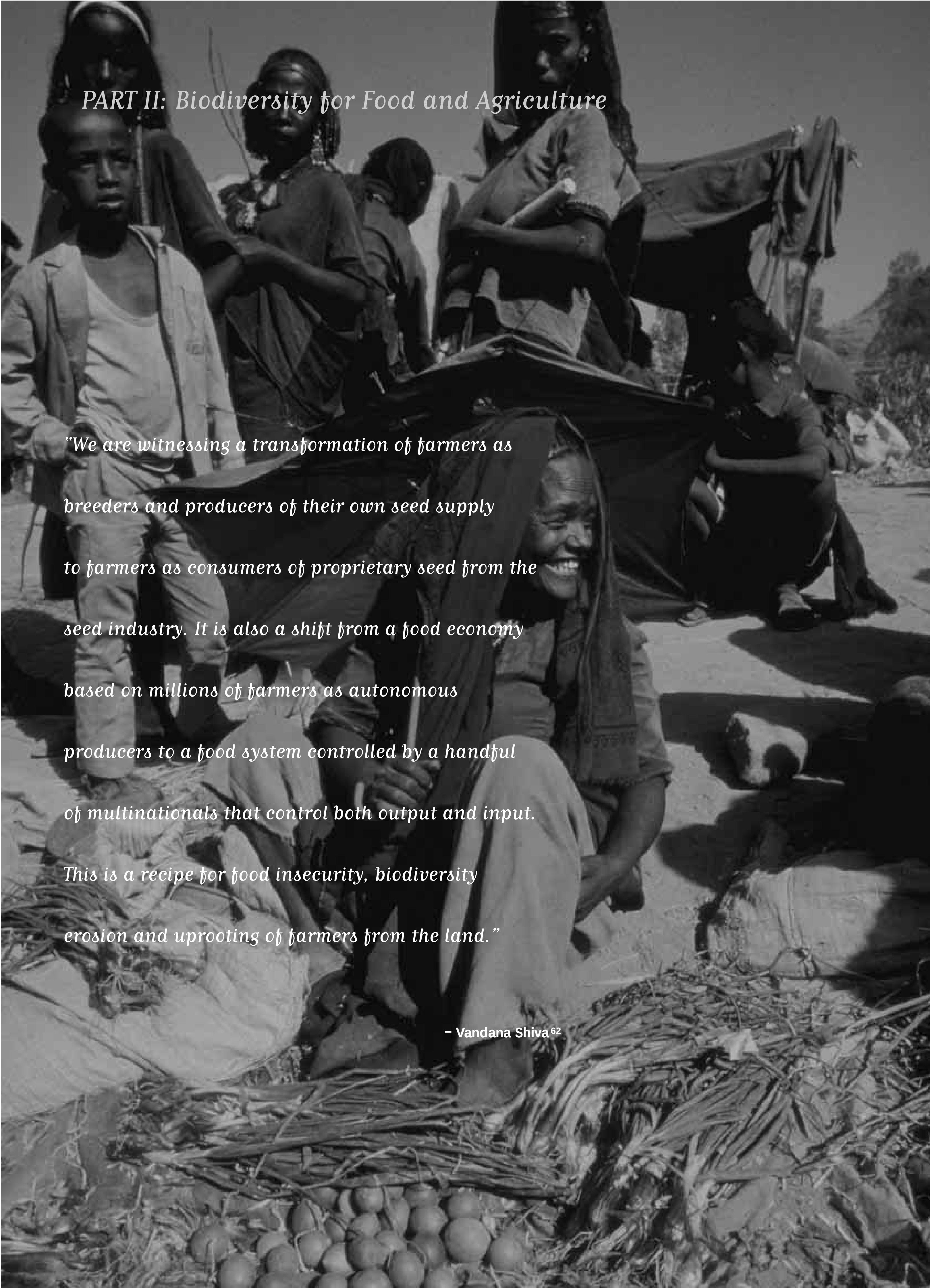
57 US Department of Health and Human Services. “Medical Products from the Natural World and the Protection of Biological Diversity,” prepared by the Fogarty International Center at the request of US Senate Committee on Appropriations after FY 1994 (nd). Internet URL: http://www.intr.net/napenet/sen-rep.html.

58 ”Paracelsian Discovers 32 Chinese Herbs Inhibit AIDS”, *Biotech Reporter*, November, 1995, p. 1.

59 Letter from John M. Kane, Technology Transfer Specialist, University of Toledo, to Dr. Aklilu Lemma, dated March 9, 1995.

60 Shiva, Vandana. “Third World Network Features”, *Utne Reader*, March–April 1996.

61 Shiva, Vandana, in *Utne Reader*, March–April 1996.



PART II: Biodiversity for Food and Agriculture

"We are witnessing a transformation of farmers as breeders and producers of their own seed supply to farmers as consumers of proprietary seed from the seed industry. It is also a shift from a food economy based on millions of farmers as autonomous producers to a food system controlled by a handful of multinationals that control both output and input. This is a recipe for food insecurity, biodiversity erosion and uprooting of farmers from the land."

– **Vandana Shiva**[62]

CHAPTER 3

CROP GENETIC RESOURCES

Introduction

Products of plant origin make up an estimated 93% of human foodstuffs. How many plants feed the world? The answer depends on whom we ask, and where we look for evidence. Widely cited statistics, based on global production data, suggest that just a handful of major crop species (especially rice, wheat, maize, barley, sorghum/millet, potato, sweet potato/yam, sugar cane and soybean) supply most of the energy humans derive from plants. There's no doubt about the global economic importance of these major crops, but the tendency to focus on a small number of species masks the importance of plant species diversity to the world food supply. A very different picture would emerge if we were to look into women's cooking pots and home gardens of poor people in the South and if we could survey local markets and give special attention to household use of non-domesticated species. Of some 320,000 vascular plants, about 3,000 species (both "wild" and domesticated) are regularly exploited as food,[63] while the total number of plant species cultivated and collected by humans for food exceeds 7,000.[64] A recent study by Canadian researchers, Christine and Robert Prescott-Allen, used per capita food supply data from 146 countries and found that 103 species contribute 90% of the world's plant food supply.[65] However thousands of species contribute to the food supply of the other 10% which have considerable importance from a nutritional viewpoint and for poor people. The Prescott-Allens point out that their estimates grossly underestimate the true diversity of plant food species which excludes, for example, teff in Ethiopia.

If agricultural development policies and conservation priorities are guided by the mistaken assumption that humanity depends on a handful of commodity crops, then we run the risk of undermining food security for the poor and increasing the spectre of hunger in many areas of the world. For poor people in marginal farming areas of the South, in particular, survival depends not just on rice, maize and wheat, but on minor species – especially those that are adapted to harsh climates and poor soils – that have been neglected or ignored by institutional agricultural research.

Seeds of Survival

Some 12,000 years ago, agriculture began when farmers started to gather seeds from wild plants and began sowing them to grow food. Though frequently overlooked, it was largely women cultivators who first domesticated plants and invented grain milling.

All major food crops, the staple crops grown and consumed by the vast majority of the world's population, have their origins and centres of diversity in the tropics and subtropics of Asia, Africa and Latin America. Over the past 12,000 years, farmers in these areas selected and domesticated all major food crops on which humankind survives today.

CIDA PHOTO: DAVID BARBOUR

The Twelve Megacentres of cultivated plants

1 Chinese-Japanese Region

Soybean	*Bamboo*	*Mustard*
Rice	*Orange*	*Peach*
Millet	*Tea*	

2 Indochinese-Indonesian Region

Banana	*Coconut*	*Mango*
Sugarcane	*Rice*	
Bamboo	*Yam*	

3 Australian Region

Macadamia nut

4 Hindustani Region

Rice	*Chickpea*	*Mustard*
Banana	*Mango*	*Citrus*
Sugarcane	*Bean*	
Cucmber	*Eggplant*	

5 Central Asian Region

Wheat	*Pea*	*Melon*
Grape	*Bean*	*Carrot*
Apricot	*Rye*	*Spinach*
Pear	*Apple*	*Walnut*
Onion	*Plum*	

6 Near Eastern Region

Wheat	*Pistachio*	*Fig*
Lentil	*Barley*	*Pea*
Grape	*Rye*	
Melon	*Almond*	

7 Mediterranean Region

Wheat	*Bean*	*Lettuce*
Olive	*Cabbage*	*Grape*
Radish	*Oats*	*Celery*
Fava	*Beetroot*	

8 African Region

Wheat	*Coffee*	*Oil Palm*
Millet	*Sorghum*	*Okra*
Yam	*Teff*	

9 European-Siberian Region

Hops	*Chicory*	*Cherry*
Pear	*Apple*	*Lettuce*

10 South American Region

Potato	*Squash*	*Cacao*
Cassava	*Sweet*	*Lima*
Pineapple	*Potato*	*Bean*
Groundnut	*Tomato*	*Papaya*

11 Central American Region

Maize	*hilli*	*Squash*
Potato	*French*	
Pepper/c	*Bean*	

12 North American Region

Sunflower	*Jerusalem artichoke*	*Blueberry*

SOURCE: *FAO*

Wheat and barley originated in the Near East, for example. Soybeans and rice came from China. Sorghum, yams and coffee come from Africa. The genetic homeland of maize, tomato and cacao is Central America. The only major crop originating in North America is the sunflower.

By and large, crop genetic diversity is still concentrated in regions known as "centres of diversity," located in the developing world. Farmers in these areas who practice traditional agriculture cultivate community-bred varieties (also known as "landraces") selected over many generations. Closely related species that survive in the wild are known as "wild relatives" of crops. Both farmer's crop varieties and their wild relatives serve as the world's richest repositories of crop genetic diversity.

Thousands of different and genetically distinct varieties of our major food crops owe their existence to thousands of years of evolution and to careful selection and improvement by our farmer ancestors. This diversity protects the crop and helps it adapt to different environments and human needs. The potato, for instance, originated in the Andes, but

The Potato Blight is Back

The "late potato blight" *(P. infestans)*, the fungus that caused the Great Potato Famine of 1845–49, is not merely an historic example of the dangers of crop uniformity. One hundred and fifty years after the fungus decimated food production around the world, the blight is back again in new and deadlier forms, and today the blight poses a grave threat to food security.[84]

The new epidemic threatens not only a US$160,000 million commercial potato crop in western industrialized nations, but a major subsistence crop for the poor in many parts of Africa, Asia and Eastern Europe. In 1992, the International Potato Centre estimated that late blight was already cutting Third World potato yields by 30% despite expenditures of $600 million can be found today growing below sea level behind Dutch dikes, or high in the Himalayan mountains. One variety of rice grows in 7 and one-half meters of water, while another survives on just 60 centimeters of annual rainfall.

Agriculture's Vanishing Heritage

Today, much of this diversity is being lost. Many unique varieties are disappearing and becoming extinct. The FAO estimates that since the beginning of this century, about 75% of the genetic diversity of agricultural crops has been lost. "Genetic erosion" refers to the loss of genetic diversity between and within populations of the same species.

Nearly all of the 158 countries that submitted background reports for FAO's State of the World Report on Plant Genetic Resources identify genetic erosion as a serious problem. In China, for example, nearly 10,000 wheat varieties were cultivated in 1949. By the 1970s, only about 1,000 varieties were in use.[66] In Mexico, genetic erosion of maize is well documented. Only 20% of the maize varieties reported in 1930 are now known in Mexico.[67]

The primary reason for the loss of crop genetic diversity is that commercial, uniform varieties are replacing traditional varieties – especially in the South's centres of diversity. When farmers abandon their community-bred varieties to plant new ones, the old varieties become extinct.

The "Green Revolution" refers to the development of high-yielding grains that were introduced by international crop breeding institutions beginning in the 1950s. The spread of new varieties was dramatic. By 1990, Green Revolution varieties covered half of all wheat lands, and more than half of all rice lands in the South – a total of some 115 million hectares. In the process, new and uniform cultivars from both the public and private sectors replaced community-bred varieties on a massive scale.

Erosion of crop genetic diversity threatens the existence and stability of our global food supply. The diversity found in the South is vital for the maintenance and improvement of new crop varieties. To maintain pest and disease resistance in our major food crops, for instance, or to develop other needed traits like drought tolerance or improved flavor, plant breeders constantly require fresh infusions of genes from the farms, forests and fields of the South. The high-yielding, elite cultivars of industrial agriculture depend on a steady stream of new, exotic germplasm.

Dangers of Genetic Uniformity

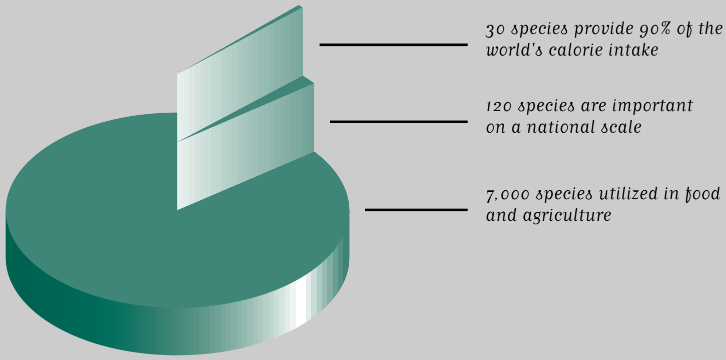
Industrialized agriculture favours genetic uniformity. Vast areas are typically planted to a single, high-yielding variety or a handful of genetically similar cultivars using capital intensive inputs like irrigation, fertilizer and pesticides to maximize production. A uniform crop is a breeding ground for disaster because it is more vulnerable to epidemics of pests and diseases. A pest or disease that strikes one plant spreads quickly thoughout the crop.

The Irish Potato Famine of the 1840s is a dramatic example of the dangers of genetic uniformity. Potatoes originated in the Andes mountains of South America. In the 1500s,

per annum on fungicides to control the blight. The same year scientists noticed that two strains of *P. infestans,* types A1 and A2, were mutating and sexually reproducing. The newest forms are resistant to the only chemical fungicide used to control late blight.

The re-emergence of the deadly late potato blight is a stark reminder of the dangers of genetic uniformity and the inadequacy of industrial breeding strategies which depend on over-zealous dissemination of single genes, reliance on a handful of commercial potato varieties, and a single chemical control. Ultimately, it is the indigenous farming communities of Mexico, Central America and the Andes who have long maintained and improved genetically-diverse potatoes, who offer the most promise for development of disease resistant potato cultivars and sustainable farming systems.

Estimated Numbers of Food Crop Species



SOURCE: *FAO*

when New World potatoes were introduced into Europe, none of the introduced varieties were resistant to a fungus that struck Ireland's potato crop in the 1840s. When the disease struck, the potato crop was wiped-out. Over 1.5 million people died in the famine. The potato blight is not merely an historical footnote in a long list of crop epidemics. The same fungus, in new and more virulent forms, today poses a grave threat to food security. (see box, "The Potato Blight is Back")

In 1970, genetic uniformity in the United States maize crop was responsible for destroying almost $1 billion worth of US maize, and reducing yields by as much as 50%. The problem was that over 80% of the commercial maize varieties being grown in the United States at that time carried a gene that made them genetically susceptible to a virulent disease known as southern leaf blight. Further catastrophe in maize was averted due to intensive breeding programmes. The epidemic and its consequences for food security drew worldwide attention to the problem of genetic vulnerability in major food crops.

Are crops more or less vulnerable today than in 1970? In 1993, plant breeder Garrison Wilkes observed that, "Clearly our priorities with regard to genetic vulnerability and food stablility strategies are deficient to non-existent."[68] In the South, genetic diversity in rice, wheat and maize has steadily eroded due to the dominance of a handful of high-yielding Green Revolution varieties. In Bangladesh, for example, Green Revolution wheat varieties covered about 96% of the wheat area in 1984 with 67% of the wheat land planted to a single variety.[69] In the Philippines, two rice varieties developed by the International Rice Research Institute (IRRI) occupied about 90% of the entire rice-growing area during the 1984 dry season.[70] With intensive cultivation of fewer rice varieties throughout the developing world, rice diseases and pests are reportedly growing in number, intensity and geographic distribution.[71] In 1993, the National Academy of Sciences' Committee on Managing Global Genetic Resources made this somber prediction about the state of genetic vulnerability in the South:

"Lack of support for public plant breeding efforts in many developing countries makes it unlikely that they will be able to mobilize new varieties in sufficient time to prevent disaster."[72]

Why is Crop Genetic Diversity so Important?

The high-yielding, elite cultivars of industrial agriculture depend on a steady stream of new, exotic germplasm. Plant breeders call this "the varietal relay race" – they are constantly trying to develop and release new varieties to stay one step ahead of thousands of pests and diseases. Without access to exotic germplasm, industrial agriculture would literally grind to a halt. The United States government estimates that for just two major crops, access to exotic germplasm adds a value of US$3,200 million to the nation's US$11,000 million annual soybean production, and about $7,000 million to its $18,000 million annual maize crop.[73] Italian scientists estimate that the benefits of exotic germplasm for a single crop, durum wheat, amount to US$300 million per year in Italy alone. Using exotic maize germplasm from Mexico, the Caribbean and Brazil, US breeders recently developed a commercial maize variety with genetic resistance to armyworm leaf damage – a pest that causes up to US$30 million in damage per annum in the southeastern United States.[74] Rust-resistant genes from an ancient sunflower variety cultivated by the Havasupai Indians of the southwestern United States are now being incorporated into sunflower hybrids in Australia, China, South Africa, India and the United States where new races of rust have threatened the commercial sunflower industry.[75]

Not only cultivated species found in the farmers' fields, but also the genes from wild relatives are enormously valuable. Canadian researchers estimate that between 1976 and 1980, wild species contributed $340 million per year in yield and disease resistance to the US farm economy. Genes from a single wild tomato species gathered in the Peruvian Andes contributes $8 million per annum to US tomato processors.[76]

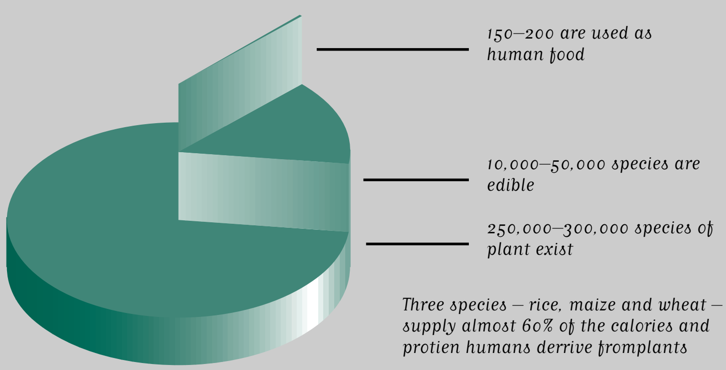
Genetic engineers at Germany's Hoechst corporation (now AgrEvo) achieved genetic tolerance of glufosinate (the company's best-selling herbicide) in crops through the introduction of two resistant genes – one of which is derived from a Cameroonian soil sample.[77] AgrEvo is one of the industry's leading developers of transgenic herbicide tolerant plants, and glufosinate is the company's flagship, with sales of over 2500 tonnes per year. (Herbicides accounted for 45% of AgrEvo's US$2,200 million sales in 1994.)[78]

Farmer-Led Food Security

Crop genetic diversity is not just a raw material for industrial agriculture; it is the key to food security and sustainable agriculture because it enables farmers to adapt crops suited to their own ecological needs and cultural traditions. Without this diversity, options for long-term sustainability and agricultural self-reliance are lost. The type of seed sown to a large extent determines the farmers's need for fertilizers, pesticides and irrigation. Communities that lose community-bred varieties and indigenous knowledge about them, risk losing control of their farming systems and becoming dependent on outside sources of seeds and the inputs needed to grow and protect them. Without an agricultural system adapted to a community and its environment, self-reliance in agriculture is impossible.

An estimated 60% of the world's agricultural land is still farmed by traditional or subsistence farmers, mostly in marginal areas.[79] A majority of the world's resource poor farmers are women. As Norwegian plant breeder Trygve Berg points out, most of the South's farmers produce food under conditions which are considered marginal, making their problems and needs far from marginal.[80] Though frequently characterized as "resource poor," many marginal farming areas tend to be extraordinarily rich in plant and animal genetic diversity and traditional knowledge.

Unexploited Biodiversity



SOURCE: *CIGAR*

The South's poor farmers in marginal areas were largely by-passed or forgotten by the Green Revolution because high-yielding seeds perform best in rainfed and irrigated regions, and their success depends on capital intensive inputs. In spite of success in raising yields and food production in some high potential areas, the Green Revolution's universalistic approach to high-input, high-yielding plant breeding has been largely unsuccessful in less hospitable, site-specific farming environments.[81] For the majority of the world's farmers, therefore, self-reliance in food production depends on adapting technologies and germplasm to a wide range of poor production environments.

Ultimately, farming communities hold the key to conservation and use of agricultural biodiversity, and to food security for millions of the world's poor. They are the innovators best suited to develop new technologies, germplasm, and management to their diverse ecosystems. As plant collector David Wood observes: "There are about 3 billion farming people in the world. They have almost infinite capacity, experience and application to select and maintain crop germplasm."[82] In the long run, the conservation of plant genetic diversity depends not so much on a small number of institutional plant breeders in the formal sector, but on the vast number of poor farmers who select, improve and use crop diversity, especially in marginal farming environments. But neither institutional breeders nor farmer breeders can succeed alone. Success depends on integrated approaches that combine the best of traditional knowledge and institutional technologies.

The challenge for the world community is to link conservation and development by enabling farm communities to assume a major role in managing and benefitting from the genetic resources on which their livelihoods depend. To succeed in these efforts, farmers must have greater control over their genetic resources, access to technologies, research information, and a wider range of genetic resources and enhanced germplasm. This requires that the formal sector (governments, scientists and institutional plant breeders) build upon the knowledge and experience of farmers, involve farmers in setting the research agenda, enable them to select and assess technologies, and work with them as partners in the maintenance and further development of their own seeds and livestock breeds.

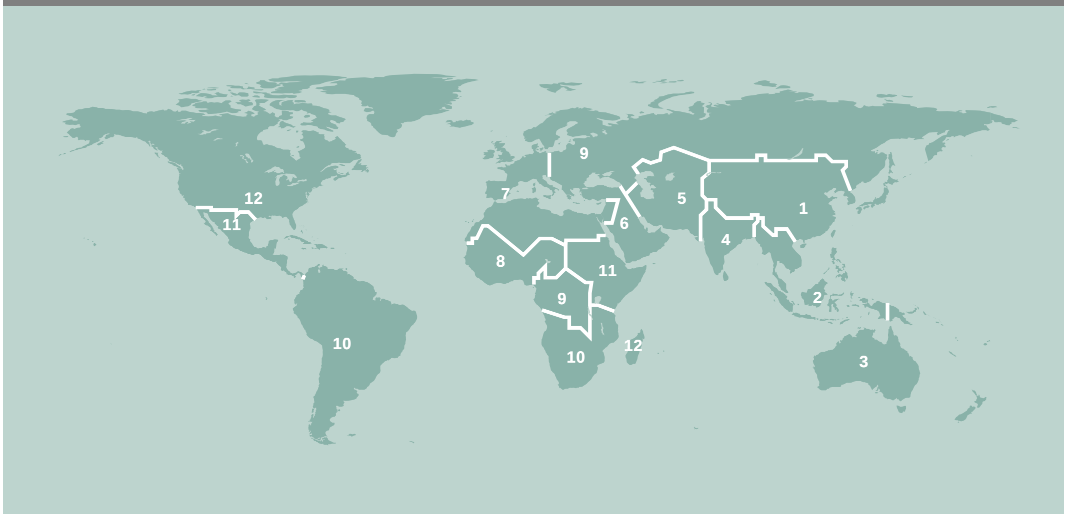
The Geopolitics of Plant Genetic Resources

The issue of control, ownership and access to plant genetic diversity has assumed immense importance in the international policy arena over the past two decades. Historically, there has been free access to plant genetic diversity found in the farms, fields and forests of the South. Seeds found in tropical centres of diversity were freely collected by Northern scientists and later introduced as the "raw materials" for plant breeding in the industrialized world. In the process, seeds collected in the South were routinely transferred to Northern-based (or controlled) gene banks for safe-keeping. Much of the collected diversity of tropical and sub-tropical origin thus came to be stored in the North, or in gene banks established by the International Research Centres under the aegis of the Consultative Group on International Agricultural Research (CGIAR).

The Politics of Poverty and Diversity: Where Should Scarce Agricultural Research Dollars Be Spent?

Some scientists have pointed out that many of the world's poorest farmers live in areas containing the richest genetic diversity. If marginal farmers living in diversity-rich regions cannot increase food production to keep pace with population growth, they argue, then why put scarce agricultural research dollars into these areas? The true path to food security, they insist, requires capital-intensive, high-technology agricultural production over subsistence farming. This neo-Malthusian approach to food security blames poor people for being poor, and suggests that poverty is the result of a natural endowment rather than inequities in social and economic systems.

Regions of diversity of major cultivated plants



1 East Asia
Prosomillet | *Orange*
Foxtail Millet | *Peach*
Soybean

2 South-East Asia
Rice | *Breadfruit*
Winged Bean | *Banana*
Taro | *Citrus*
Yam

3 Pacific
Sugarcane | *Coconut*

4 South Asia
Rice | *Mango*
Kodo Millet | *Black Pepper*
Eggplant

5 Central Asia
Wheat | *Carrot*
Onion | *Fava Bean*

6 West Asia
Pistachio | *Lentil*
Wheat | *Pea*
Barley | *Fig*

7 Southern Mediterranean
Oats | *Olive*
Beetroot | *Grape*
Artichoke | *Date Palm*

8 West Africa
Sorghum | *Cow Pea*
Yam | *Oil Palm*

9 Central Africa
Yam | *Coffee*
Kenaf | *(robusta)*

10 Southern Africa
Finger Millet | *Sorghum*
Pearl Millet | *Melon*

11 East Africa
Sorghum | *Tef*
Finger Millet | *Pigeon Pea*
Pearl Millet | *Coffee*

12 Indian Ocean
Mascarena | *Banana*
Coffee

13 Europe
Brassica ssp. | *Apple*
Forage species | *Peach*

14 South American Region
Sweet Potato | *Pumpkin*
Potato | *Tomato*
Cassava | *Cocoa*
Phaseolus ssp.

15 Central American Region
Maize | *Phaseolus ssp.*
Potato | *Sweet Pepper*
Cassava

16 North American Region
Sunflower | *Jerusalem artichoke*
Cranberry | *Hop*

SOURCE: *FAO*

Over the past 30 years, plant breeding in the industrialized world has become increasingly commercialized. In the marketplace today, plant breeding, agricultural biotechnology and commercial seed sales are now dominated by transnational seed and agrichemical corporations. Privatization of plant breeding in the industrialized world led to the development of "Plant Breeders' Rights," a system of patent-like protection that gives formal breeders private monopoly rights over the production, marketing and sale of their varieties for a period of up to 25 years. Many governments in the industrialized world adopted Plant Breeders' Rights as a mechanism to promote innovation in plant breeding and to allow seed companies to recoup their investment by collecting royalties on proprietary plant varieties. In recent years, intellectual property systems have been expanded and strengthened to afford the biotechnology industry greater control over seeds and

Side-stepping the more important issues of structural reforms, the central (and familiar) response of international agricultural research institutions is to recycle the Green Revolution, and boost it with a heavy dose of biotechnology. But if international aid and development institutions dismiss peasant farmers, exclude structural reforms and ignore the indigenous food crops and livestock breeds that poor farmers depend upon for survival, then they fail to address actual hunger. At the Science Academies Summit held in India in July, 1996 several African scientists expressed their frustration with foreign ideas for high-tech agriculture in the South, noting that traditional African crops are ignored or undervalued in international agricultural research. "I don't want a Green Revolution," said Iba Kone of the African Academy of Sciences, "I want a Black revolution. I want to return to our indigenous crops."[83]

germplasm. But intellectual property systems have evolved with little consideration for the impacts on farmers, food security and plant genetic resources. Intellectual property regimes increasingly deny farmers the right to save and propagate their seed, prohibit researchers from using proprietary germplasm (even for non-commercial purposes), and thus profoundly restrict access to and exchange of germplasm.

Beginning in the early 1980s, representatives from the South, together with NGOs, began to question the inequitable and contradictory nature of free access to plant genetic resources of the South in the face of monopoly rights for new varieties developed by industrial plant breeders. At the United Nations, South diplomats began to ask: Why are patented seeds, based on genes of Third World origin, bringing profits to transnational seed corporations without corresponding compensation for the original donors/innovators of the genetic material? Who is responsible for conserving plant genetic resources? Who controls access to genetic material, and what mechanisms are needed to ensure reciprocal benefits between the "technology rich" countries of the industrialized world and the "gene rich" countries of the South?

FAO's Global System for the Conservation and Sustainable Use of Plant Genetic Resources

Since 1983, member nations of the United Nations' Food and Agriculture Organization have taken important (and often painfully difficult and delicate) steps to resolve these contentious questions by establishing a Global System for the Conservation and Utilization of Plant Genetic Resources (PGR) for Food and Agriculture – which includes crops as well as forestry. By the mid-1990s, 171 countries and the European Community were formally part of the Global System, whose aims are:

- conservation of plant genetic resources;
- sustainable use of its components;
- fair and equitable sharing of the benefits arising from the utilization of genetic resources;

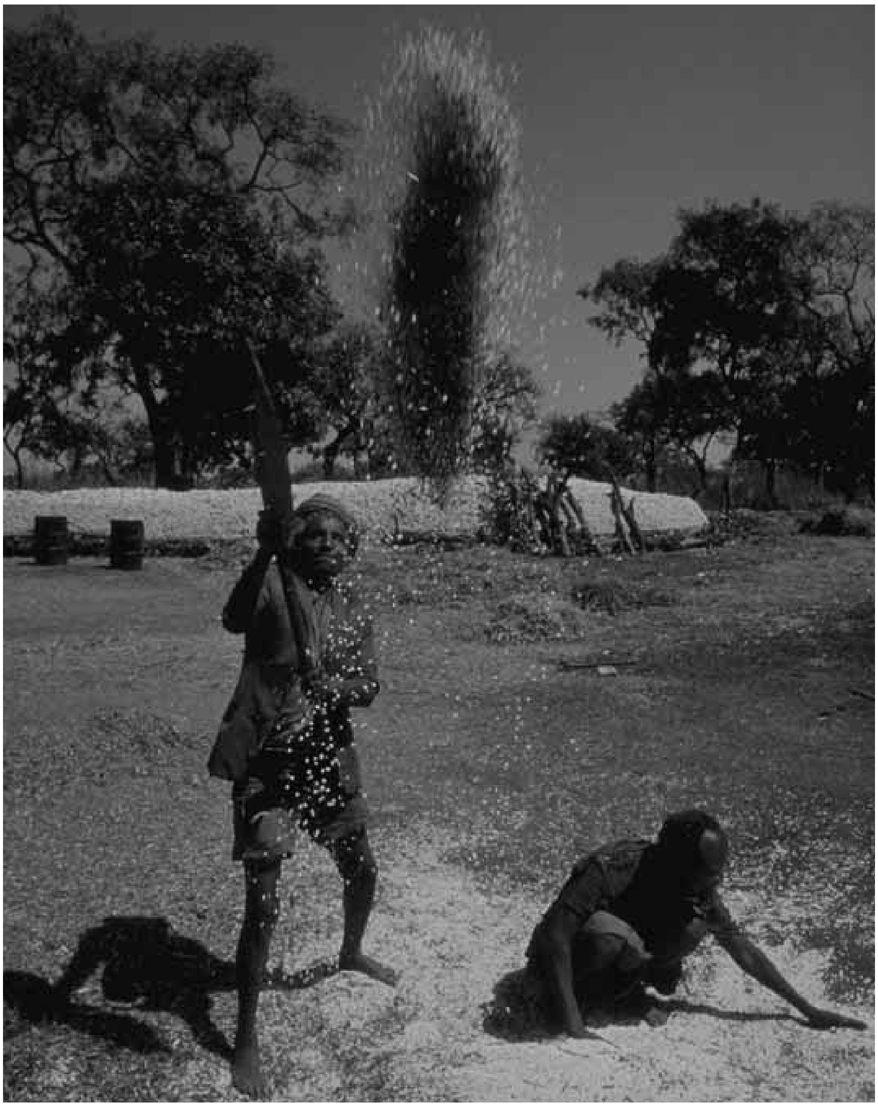
The main institutional components of the Global System are the Commission on Genetic Resources for Food and Agriculture and the International Undertaking on PGR.

The Commission provides an inter-governmental forum where countries – as donors and users of germplasm, funds and technologies – can meet, on an equal footing, to discuss and reach consensus on matters related to crop germplasm. Its mandate was broadened to include all genetic resources for food and agriculture in 1995.

The International Undertaking on Plant Genetic Resources is a non-binding agreement establishing guidelines for the use and exchange of genetic resources, subject to the sovereign rights of nations over the genetic resources in their territory. Within International the Undertaking there is a balanced recognition of Plant Breeders' Rights and Farmers' Rights. It is now in the process of being revised in harmony with the Convention on Biological Diversity (see below).

Farmers' Rights

The principle of Farmers' Rights, endorsed by the FAO in 1989, recognizes the fact that farmers and rural communities have contributed greatly to the creation, conservation, exchange and knowledge of genetic resources, and that they should be recognized and rewarded for their past and ongoing contributions. Farmers' Rights acknowledges that farmers who have consciously selected and improved crop genetic resources since the origins of agriculture should be rewarded no less than plant breeders who benefit from Breeders' Rights (patent-like monopolies on new plant varieties). Many governments and NGOs have embraced the principle of Farmers'



CIDA PHOTO: DAVID BARBOUR

Unfinished Business: Agricultural Biodiversity from Rio to Leipzig and Beyond

In December, 1993 – one decade after the founding of FAO's Commission on Genetic Resources – the Convention on Biological Diversity (CBD) came into force, providing an international legally-binding framework for the conservation and sustainable use of biodiversity worldwide. But the existence of the CBD did not mean that FAO's Commission and its expertise in agricultural biodiversity suddenly became obsolete or redundant. On the contrary, the CBD and UNCED's Agenda 21 recognize that genetic resources for food and agriculture warrant discrete strategies and action within the wider context of plant genetic resources in general. While the Conference of the Parties to the CBD continues to debate important issues such as access to genetic resources, intellectual property rights, indigenous knowledge, and biosafety, a parallel process has been underway at FAO to deal with

Rights, not only as a counterpoint to Plant Breeders' Rights, but also as recognition of the innovative role that farmers and rural communities play in the conservation and further development of genetic resources and their right to benefit from it.

The principle of Farmers' Rights recognizes the past, present and future contribution of farmers in conserving, improving and making available plant genetic resources, and that they should be rewarded for their contributions. It is important to stress that RAFI's understanding of Farmers' Rights extends beyond the issue of compensation for farmers and farming communities; it includes rights to land and secure tenure, the farmer's fundamental right to save seed and exchange germplasm (in direct contradiction to evolving intellectual property regulations), and the right of farming communities to "say no" – to choose not to make their germplasm and knowledge available.


CIDA PHOTO: BRUCE PATON

the unique situation facing agricultural biodiversity. FAO's work must be carried out in harmony with the CBD.

This work includes revision of the International Undertaking. Specifically, FAO was asked to take action on two critical issues left outside of the Convention: access to *ex situ* collections, and the question of Farmers' Rights (see next chapter for discussion of *ex situ* collections).

In short, FAO's role has been to give greater prominence and visibility to the critical social and economic importance of agricultural biodiversity within the legally binding scope of the Convention. In the early 1990s, FAO spearheaded an international, country-driven process designed to ask critical questions about the state of the world's agricultural diversity, and to identify the actions needed to insure that it is conserved, utilized and further

Biotechnology: Opportunity or Obstacle for Development?

Access to biodiversity is the lifeblood of commercial biotechnology. The genes from plants, animals and microorganisms that flourish in the forests, fields and seas of the South are the strategic "raw materials" for the development of agricultural, pharmaceutical and industrial products.

Genetic engineering is the most powerful tool of biotechnology. Scientists can now transfer genes – the biological instructions that determine what any living organism looks like and what it can do – between unrelated species and thus create novel plants, animals and microorganisms with properties they could never have acquired naturally. Today, genetic engineers are creating crops that contain insecticidal genes from soil organisms, fish with human growth hormones, and faster growing trees.

Despite the powers of new biotechnologies, it is important to stress that genetic engineering cannot replace material lost through extinction, nor will it eliminate the need to conserve biological resources.

Globally, transnational seed and agrichemical corporations are the leading players in agricultural biotechnology. With few exceptions, scientific and technical capacity in the biosciences is highly concentrated in industrialized nations. By and large, current biotechnology research does not focus on the needs of poor farmers in marginal farming areas of the South, and has little to do with feeding hungry people. Agricultural biotechnology is controlled by a handful of seed, agrochemical and pharmaceutical corporations, whose proprietary products are targetted for industrial consumers in the North. Consider, for example, that one plant developed. The 4-year preparatory process drew on the active participation of all major actors in the bio-policy and conservation arena – including national governments, scientific institutions, NGOs, farmers' organizations and other community-based conservation experts.

The preparatory process culminated in June, 1996 when high-ranking officials from ministries of agriculture, foreign affairs and the environment of some 150 countries gathered in Leipzig, Germany for FAO's *Fourth International Technical Conference on Plant Genetic Resources for Food and Agriculture.* It was the most important meeting on agricultural biodiversity ever held. The Leipzig Conference adopted the first-ever *Global Plan of Action for the Conservation and Sustainable Utilization of PGRFA.* The Global Plan represents the input of 158 countries, scientific experts and NGOs, and the synthesis of over 2000 recommendations resulting from regional meetings and country reports. It identifies 20 priority programmes for securing and better utilizing PGR as a basis for global food security which will cost approximately US$131 million to $304 million per annum (1997–2007).

The Leipzig Conference also considered the *FAO Report on the State of the World's Plant Genetic Resources,* based on reports submitted by 158 countries. The State of the World report provides the first comprehensive assessment of the status of plant genetic resources and existing capacity to conserve and utilize them.

The governments which met in Leipzig recognized that the Global Plan of Action cannot be implemented successfully unless Farmers' Rights are realized. At Leipzig, delegates also identified the need for "new and additional" financial support to implement the GPA. The follow-up process now underway requires governments to secure adequate financing to implement the Plan, and realize Farmers' Rights.

An *International Undertaking* which contains a set of legally binding provisions covering ownership, access to and exchange of plant genetic resources, is now being revised through negotiations between countries. It is this instrument that will establish the rules of the game on access to agricultural biodiversity and Farmers' Rights. Ultimately, the revised International Undertaking may be considered as a protocol to the Convention on Biological Diversity.

biotech company, DNA Plant Technology, spent over $6.3 million defending its biotech patents on technology for longer shelf-life tomatoes.[85] Monsanto spent no less than $100 million developing its herbicide tolerant soybean.[86] Pioneer Hi-Bred, the world's largest seed corporation, claims that the development of its genetically engineered, insect resistant maize hybrid required access to 38 different patent claims involving 16 separate patent holders.[87]

In some cases, biotech research threatens to reduce or eliminate tropical export commodities, jeopardizing the livelihoods of millions of agricultural workers in the South. In fact, emerging biotechnologies may add new dimensions to existing inequities, and thus aggravate rather than alleviate the problems of the poor.

- Pacific Northwest Laboratory (Washington, USA) is using a strain of sulfur-loving bactertia to recycle rubber used in discarded tires.[88] The goal of the project is to make tires with 80% new rubber and 20% recycled rubber. If successful, microbially-treated recycled rubber could take a large bite out of natural rubber exports from the South – valued at approximately $4,700 million in 1994.[89]
- In 1995, Calgene Inc. (USA) commercialized a genetically engineered rapeseed (or canola) that produces the lauric fatty acid, a product previously derived only from tropical oils – primarily coconut oil. If successful, lauric-producing rapeseed could be grown on a large-scale in the temperate North, displacing tropical lauric oil imports, valued at over $350 million in 1992.[90]
- In 1995, AgriDyne Technology (USA) received US Patent No. 5,443,978 for an enzymatic process of producing "biopyrethrum" in the laboratory. Pyrethrum is a natural insecticide extracted from chrysanthemum flowers grown by East African farmers. If AgriDyne's technique is commercially successful, over 100,000 small farmers in Kenya alone risk losing a major export commodity valued at over US$35 million in 1994.[91]

Biosynthesis (laboratory production) of tropical commodities such as lauric oils, pyrethrum and rubber will ultimately transfer production out of farmers' fields in the South into industrial bioreactors in the North. Without ample opportunity to plan and diversify, Third World farmers and their export commodities will suffer massive displacement, wreaking havoc on many debt-ridden economies.

In Leipzig, the world community reached consensus on a blueprint for sustainable management and use of plant genetic resources. Perhaps most importantly, the Leipzig process generated the political momentum necessary to fuel ongoing debate. Will FAO's Commission on GRFA seize the opportunity to steer the global process forward? The FAO Commission continues to be the world's premiere forum for policy and programme debate on agriculturally-important plant genetic resources. If the Commission's work cannot be maintained and strengthened, and if the Commission does not work aggressively to achieve a protocol, the world will lose an important voice for Farmers' Rights and for the equitable and sustainable conservation and use of plant genetic resources.

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"On-farm conservation is not a new concept to Ethiopian farmers. They have been conserving and utilizing indigenous landraces from the dawn of agriculture until the present time. All that is required is to encourage them to continue to use something they already do, planting landraces for both subsistence and commercial purposes.

– Tesfaye Tesemma, Ethiopia's Biodiversity Institute[92]

CHAPTER 4

CONSERVATION AND USE OF PLANT GENETIC RESOURCES

Introduction

The two basic approaches to conservation are *in situ* and *ex situ* methods. *In situ* refers to maintaining plants and animals in their original habitat, most notably in farmers' fields (also known as on-farm conservation). *Ex situ* conservation refers to maintaining organisms outside their original habitats in facilities such as genebanks, field genebanks or botanical gardens.

Experience shows that diversity is only secure when diverse conservation strategies are employed. *Ex situ* and *in situ* approaches are not mutually exclusive; no single method of conservation is optimal for all situations, and no single method can succeed alone. Different conservation systems can complement each other and provide insurance against the shortcomings of any one method. Ultimately, the success of both *in situ* and *ex situ* approaches depends on forging strong links between the two. In practical terms this means conservation and utilization using both institutional scientific innovation and the community genius of farmers and indigneous peoples.

Background: Ex Situ Conservation of PGR

In response to the alarming pace of crop genetic erosion, particularly in the South's centres of diversity, FAO, Consultative Group on International Agricultural Research (CGIAR) and various national governments initiated global plant genetic conservation efforts in the early 1970s. Collecting missions were launched to Southern centres of diversity, and gene banks were constructed and expanded for safeguarding collected germplasm. To date, the storage of seeds in gene banks has been the standard approach to plant genetic resource conservation. The vast majority of attention, funds and scientific expertise has been devoted to *ex situ* collections, focusing particularly on major crop species.

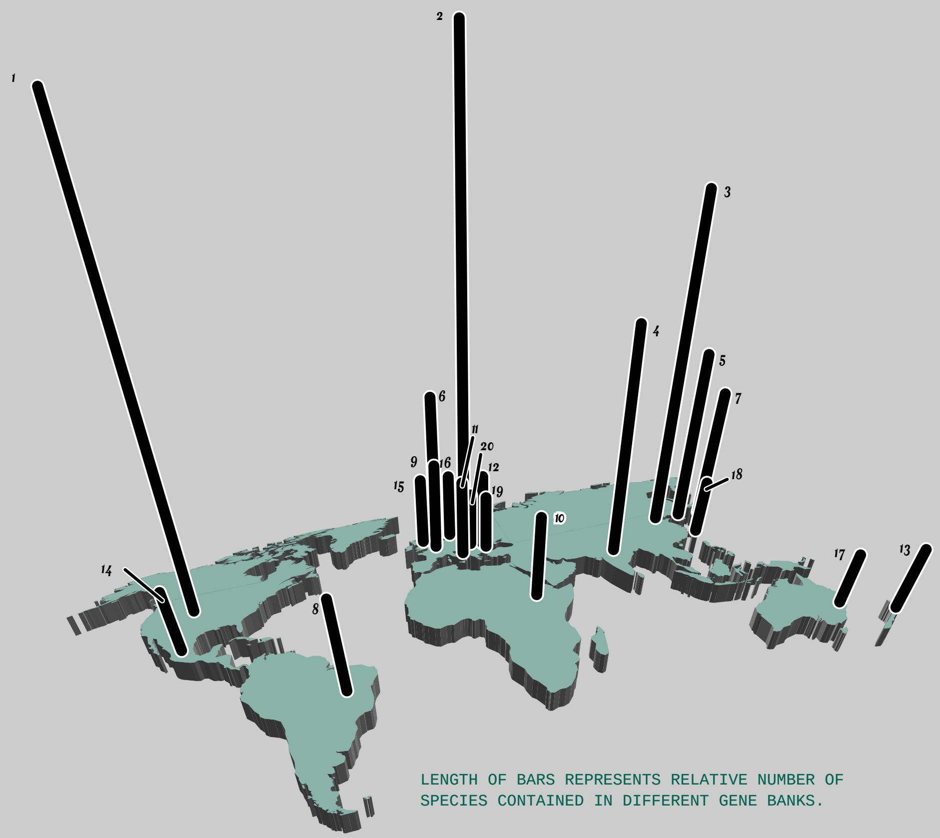
Where is Collected Germplasm and Who Controls It?

The majority of *ex situ* plant germplasm is currently located in Northern institutions or is being conserved in gene banks developed and maintained by the International Agricultural Research Centres (IARCs) of the CGIAR. The IARC gene banks are located primarily in the South but their funding and guidance comes primarily from Northern donors. The objective of the agreed undertaking between the CGIAR centres and FAO with respect to these collections is to ensure that all germplasm samples are stored in duplicate and that they are freely accessible.

The IARCs hold over 600,000 seed samples in their genebanks which, according to some estimates, amount to between 20% and 50% of all unique germplasm in storage

CIDA PHOTO: CINDY ANDREW

The world's major national plant gene banks



1 National Seed Storage Laboratory, Colorado, USA
2 N I Vavilov Research Institute of Plant Industry, St Petersburg, the Russian Federation
3 Institute of Crop Germplasm Resources, Bejing, China
4 National Bureau of Plant Genetic Resources, New Delhi, India
5 Genetic Resources Division, Agricultural Biotechnology Institute, Suweon, Republic of Korea
6 Institute of Plant Genetics and Crop Research, Gatersleben, Germany
7 Department of Genetic Resources, National Institute of Agrobiological Resources, Japan
8 National Research Centre of Biotechnology, Brasilia, Brazil
9 Institute of Crop Sciences, Braunschweig, Germany
10 Plant Genetic Resources Centre, Addis Ababa, Ethiopia
11 Germplasm Institute, Bari, Italy
12 Genetic Resources Department Research Institute for Cereals and Industrial Crops, Fundulea, Romania
13 New Zealand Germplasm Centre, Palmerston, New Zealand
14 National Institute for Ariculture Research, Chapingo, Mexico
15 Institute of Plant Science Research, Norwich, UK
16 Plant Breeding and Acclimatization Institute, Radzikow, Poland
17 Australian Winter Cereals Collection, Tamworth, Australia
18 The Asian Vegetable Research and Development Centre, Taiwan, Province of China
19 Institute of Introduction and Plant Genetic Resources, Sadovo, Bulgaria
20 Research Centre for Agrobotany, Tapioszele, Hungary

SOURCE: *FAO*

worldwide.[93] Because these gene banks contain "inventoried" germplasm, their collections are considered among the most valuable genetic materials simply because they are more readily identifiable and accessible to institutional plant breeders than farmer's varieties or "wild" crop relatives. The IARCs have been used principally for agricultural research in Asia, Africa and Latin America. But the North also benefits enormously from the agricultural genetic material they contain. The Rural Advancement Foundation International estimates that farm-gate prices in Europe, North America, Australia and New Zealand have risen by up to $5,000 million per annum, thanks to seed improvements based on genetic material from 12 IARC gene banks.[94]

Nobody disputes the fact that the vast majority of crop germplasm in storage was collected from the fields and forests of the South's farming communities. But to whom that treasure ultimately belongs, and to whom a genebank is accountable, has been the subject of enormous controversy and debate. The Biodiversity Convention explicitly excludes all *ex situ* genebank collections from its scope (Article 15, paragraph 3). This means that all *ex situ* collections found outside the country of origin that were acquired before the

Convention entered into force are not subject to national sovereignty, nor provisions for prior informed consent or sharing of benefits.

In October, 1994, the CGIAR and FAO signed an agreement that places the gene bank material from 12 IARC's under the auspices of FAO, to be held "in trust" for the world community. This agreement is an important first step in a process to achieve full intergovernmental responsibility over some of the world's most important seed stocks. Other crucial issues on *ex situ* germplasm must be addressed: Who controls samples of the South's germplasm held in the North? Who owns the myriad of accessions collected by CGIAR that have since been passed on to other gene banks for storage? How can the genetic material in gene banks continue to be made available without restriction, especially in a global environment where genetic resources are being privatized, and where virtually all biological materials are subject to monopoly control under intellectual property regimes? How can farmers and farming communities be adequately compensated for the creation and management of genetic resources?

There are three major forms of ex situ conservation

Seed genebanks *provide a controlled environment where seeds can be dried to low moisture content and stored at low temperature without losing their viability. Approximately 90% of all "ex situ" accessions are stored as seeds.*

Field genebanks *such as arboreta, plantations and botanical gardens are useful for species that are difficult or impossible to store as seed, including vegetatively propagated crops and tree species. Field genebanks account for approximately 8% of all accessions in "ex situ" storage.*

In vitro *methods conserve plant parts, tissue or cells in a nutrient medium. This method is used to conserve species that do not readily produce seeds, or where the seeds cannot be dried without damaging them. Only 1% of all accessions are held "in vitro".*

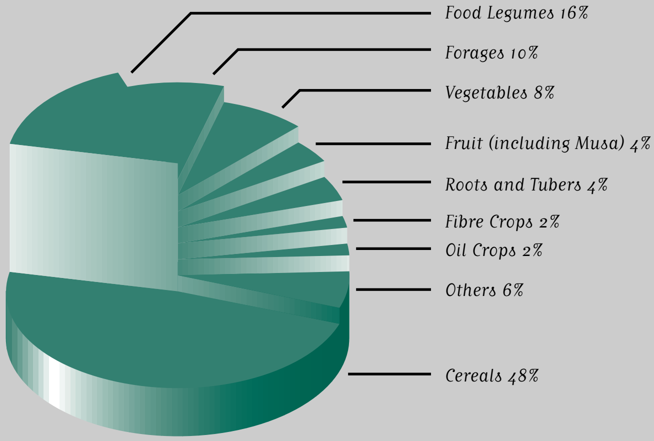
The Ex Situ Experience: Preserving Much, Using Little, and Losing a Great Deal

Ex situ collections of PGR are an essential foundation of global food security and sustainable agriculture. But more than a quarter century of practical experience with gene bank collections reveals a striking and disturbing paradox: The conventional *(ex situ)* approach to conservation of plant genetic resources has resulted in preserving much, using little, and losing a great deal. Plant genetic resources are under-conserved and under-utilized.[95] RAFI and many other NGOs point out that because *ex situ* germplasm is removed from its cultural and environmental context, these collections of crop genes have become largely inaccessible to those who have the greatest need for them – farming communities in the South – the donors and original innovators of much of the germplasm stored in gene banks.

FAO's 1996 State of the World Report on PGRFA provides the first comprehensive analysis of *ex situ* conservation worldwide. It finds that more than six million accessions are now stored in over 1300 genebanks around the world. But the numbers are deceiving. Physical infrastructure does not guarantee safe or secure storage. Problems with equipment, maintenance and funding are rampant. Many genebanks consist of nothing more than a single refrigerator operating on an unreliable power supply; many have problems with seed-drying prior to storage. A closer look reveals that the number of facilities offering secure storage for long-term conservation amounts to a handful of banks concentrated in just a dozen countries.[96]

- Of 1300 national and regional germplasm collections, 397 are suitable for medium-to long-term storage (measured by internationally-accepted criteria).
- Only 35 countries operate long-term seed storage facilities.

Contribution of major crop groups to total *ex situ* collections



SOURCE: *FAO*

- Approximatlely 45% of all accessions held in national collections are found in 12 countries (Brazil, Canada, China, France, Germany, India, Japan, Korean Republic, Russia, Ukraine, UK, USA).
- Worldwide, the number of unique accessions is estimated to be one to two million.

What's in the Banks?

Over 40% of all accessions in genebanks are cereals.[97] Food legumes constitute about 15% of global *ex situ* collections. By and large, minor and subsistence crops, farmer's varieties (landraces) and their wild relatives are poorly represented. While cereals clearly play a dominant role in food security worldwide, the disproportionate share held in gene banks also reflects the fact that they are the species most important for agricultural trade and Northern agriculture. In reality, poor people are less dependent on major crop commodities. Many of the plant species most vital to subsistence farmers and the household food security of millions of poor people in the South, including non-domesticated species, are grossly under-represented in genebank collections. Wheat, for example, accounts for 14% of total *ex situ* collections, while cassava, a major poor people's crop, accounts for only 0.5%. Vegetables, roots and tubers, fruits and forages each account for less than 10% of global collections. There are only about 11,500 accessions of all species of yams (0.18% of total accessions) and still fewer bananas and plantains (10,500 accessions).[98]

For half of all accessions in national genebank collections no information is available about the type of material stored (whether the sample is a farmer's variety [landrace], wild crop relative, or cultivar developed by institutional breeders). Where this information is available, FAO's database reveals that 48% of all accessions are cultivars or breeding lines, 36% are farmers' varieties (landraces), and only 15% are non-domesticated plants or crop relatives.[99]

Ethiopia's Biodiversity Institute: A National Genebank Working with Farmers

Ethiopia is one of the world's richest centres of crop genetic diversity. Recognizing the importance of indigenous genetic resources for the food and livelihood security of the country's growing population, Ethiopia's Biodiversity Institute has promoted on-farm conservation and enhancement of farmer's traditional crop varieties since 1988. This community-based approach combines on-farm conservation and crop improvement with training, technical support and back-up assistance from gene bank scientists and extension workers.

Farmers are assisted in mass selection (choosing seed for the next season from

Need for Regeneration

Genebank storage is not indefinite. Seeds and tissues deteriorate with age. Samples in storage must be grown into whole plants periodically (regenerated), so that a fresh generation of seeds and tissues can be taken for continued preservation. FAO finds that many seeds are stored under inadequate conditions, and "an alarmingly high number" of stored accessions is in need of regeneration.[100] Worldwide, almost half (48%) of all stored seeds need to be regenerated. (Only Japan, Ethiopia and Poland report less than 10% of total genebanks accessions in need of regeneration.)[101] As a result, some gene banks could be storing more dead than alive seed. Nobody knows how much genetic material has already been lost, but seed experts have long speculated that genetic erosion in genebanks exceeds that in farmers' fields.

Even the most technologically sophisticated gene banks cannot always provide adequate security. A review of the US National Plant Germplasm System between 1979–1989 found that 29% of the accessions in its national genebank had germination rates that were either unknown (21%) or less than 65% (8%).[102] One of the world's largest genebanks, the Vavilov Research Institute of Plant Industry in Russia, lacks long-term storage facilities and must regenerate its entire collection every few years.[103]

Lack of Characterization and Documentation

The germplasm held in many gene banks is largely unknown and undocumented. Without basic "passport," characterization and evaluation data, stored seeds are virtually useless to farmers and institutional breeders. Passport data refers to the accessions' sampling date and site of origin; characterization data refers to taxonomic information that describes the stored variety; evaluation data refers to agronomic properties of the accession.

FAO's State of the World Report concludes that documentation of *ex situ* collections is inadequate; 55 countries report the need for improvement.

Passport data is available for some 37% of the accessions held in national collections, and most accessions held in CGIAR genebanks.[104] However, the amount of information is minimal, sometimes only providing country of origin. Ethnobotanical information on the history and local uses of germplasm is rarely included.[105]

Duplication Dilemma

"Safety duplication" refers to the need for duplicate samples of unique germplasm accessions to be held in more than one genebank as a form of insurance against loss. There are two problems associated with duplication:

1) Many countries reporting to FAO state that their genebank collections are only partially duplicated; others report no duplication. Only 11 countries (accounting for a total of 430,000 accessions) reported that their collections were fully duplicated.
2) Many samples held in genebanks are either unknown or *over*-duplicated – a wasteful and expensive practice. A 1987 study of 2.5 million accessions worldwide concluded that

the best plants in the current season) to improve their native varieties. The farmers, mostly women, select for important characteristics such as qualities of the straw, grain colour and taste, and other criteria of local importance. The seeds of selected plants are harvested, and a new, improved population is used as the future seed supply. After about 3–5 seasons of selection and multiplication, improved crop yields are normally found. The Biodiversity Institute has found that improved, farmer-bred varieties are more productive than commercial varieties when grown under low-input conditions on marginal soils. Participating farmers have access to the genetic resources of the Centre's genebank, as well as technical assistance for selection and further plant breeding. The result is a two-way exchange of genetic materials and knowledge that promotes productivity while maintaining genetic diversity.

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35% of the stored accessions for 37 crops were distinct, while the rest were duplicates.[106] More recent information is not available, but FAO concludes that, "it must be assumed that inadvertent duplication is now even higher."[107]

Despite the hard work and dedication of the scientists involved, large collections of germplasm are being lost due to technical and financial shortcomings, or natural disasters. Power failures, inadequate documentation and evaluation, or failure to regenerate plants can result in massive losses of stored collections. Earthquakes, flood, and war also put genebank collections at risk.

Perhaps the biggest shortcoming of gene banks is the fact that, once stored, seeds are removed from the evolutionary process that a species undergoes in its natural environment. There is no pressure to adapt to changing natural conditions, nor to compete with other species. In addition, germplasm that only exists in gene banks is detached from its social and cultural context. The farmers who grow traditional crop varieties are not only custodians of diversity, but also carriers of knowledge which may be equally valuable in identifying and using genetic resources.[108] Unfortunately, FAO concludes that in the rush to deposit farmers' seed in gene banks, the people and farming systems that generated and

Botanical Gardens

Botanical gardens play a surpisingly important role in conserving plant biodiversity for food and agriculture as well as for medicinal purposes. There are an estimated 1,500 botanical gardens in the world that have been estimated to collectively hold samples of about half of the world's vascular plant varieties.[112] One hundred and twenty botanical gardens maintain collections of crop species, while 170 have known medicinal and forest species collections. Approximately 75% of the germplasm conserved in botanical gardens worldwide is located in North America and Europe.

Controversy over access to botanical garden collections erupted in mid-1996 when it was disclosed that pharmaceutical corporations such as GlaxoWellcome, Merck, Pfizer and Phytera were attempting to purchase tropical plant samples from some botanical gardens in the North.[113] Buying plant germplasm held in Northern botanical gardens may be easier and more convenient than negotiating access with countries of origin in the South, but it is a giant loophole and clear violation of the spirit – if not the law – of the Convention on Biological Diversity. This loophole in the Convention must be filled.

maintained the diversity being collected and stored were "scarcely appreciated and rarely considered important to conservation."[109]

Sustainable Conservation Strategies: Linking *Ex Situ* and *In Situ* and Bridging the Gap Between Institutional and Community Systems

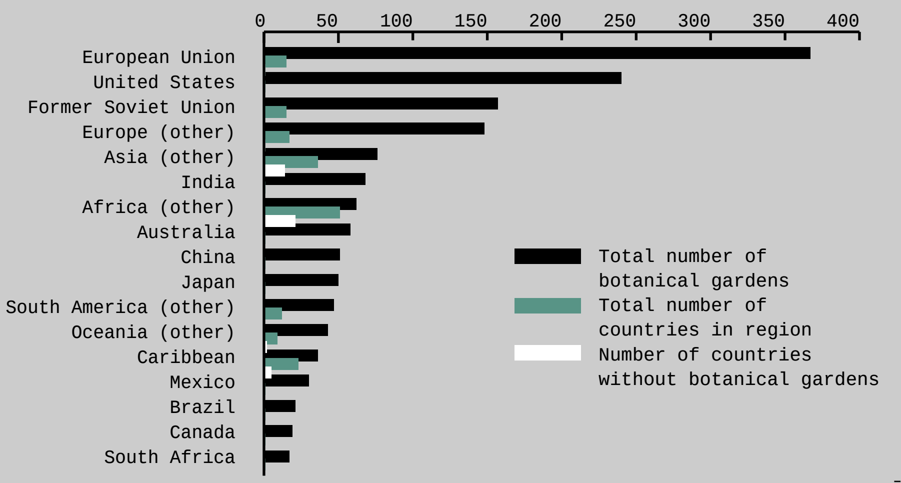
Today, there is growing appreciation for the fact that *in situ* conservation is a crucial element in the conservation of agricultural biodiversity and must be complementary to gene bank collections. The future of world food security depends not just on stored crop genes, but on the people who use and maintain diversity on a daily basis. After decades of neglect in official circles, the CBD, Agenda 21 and FAO's Global Plan of Action aim to redress this imbalance by placing greater emphasis on *in situ* and farmer/community level management of genetic resources. The Global Plan recognizes the need for complementary conservation systems and aims to secure existing *ex situ* collections while strengthening *in situ* conservation and the capacity of farming communities.

Largely due to the work of NGOs, the great untapped potential of on-farm seed conservation and plant breeding has been recognized internationally. NGOs have spearheaded community-level conservation efforts. In 1991, the Keystone Dialogue on PGR affirmed the significant contribution of community level efforts in improving, conserving and using PGR. Keystone's final report estimated that the dollar value of NGO programmes to stimulate and facilitate on-farm conservation in at least 35 countries exceeded $7 million per annum.[110] It recommended that this work be recognized, rewarded and strengthened.

The Biodiversity Institute of Ethiopia was the first national gene bank to provide an active role for farmers in genetic resource conservation. Since 1988 it has supported an innovative native seed conservation and utilization programme involving farmers, scientists and extension workers. With support from USC Canada and a consortium of NGOs, the African "Seeds of Survival Programme" has enabled scientists and local farmers to work together to restore, develop and re-introduce traditional Ethiopian crop varieties that were endangered by drought and war. The Programme is now being replicated in other African countries.

NGOs have pointed out that the "formal" world of research institutes, gene banks and plant breeders has sometimes worked against "informal" farmer-based systems, thus effectively limiting the capacity of both to operate. In January, 1993 a group of governmental and non-governmental organizations from Asia, Africa, the Americas and Europe launched the Community Biodiversity Development and Conservation Programme, a long-term initiative to strengthen local level genetic resources management. The programme's main

Number of botanical gardens



CIDA PHOTO: DAVID BARBOUR

focus is on *in situ* and on-farm conservation. The objectives of the 4-year programme, involving 15 partner organizations worldwide, are:

1) To provide direct support in strengthening community innovation systems;
2) To investigate and assess selected community innovation systems related to the conservation and use of PGR; and
3) To recommend ways in which the institutional system can better support and/or implement community innovation systems.[111]

Farmers can and do conserve, effectively use and improve plant genetic resources. This approach must be supported – not impeded – by the institutional plant breeding or *ex situ* conservation system. Ultimately, it is vital that the link be strengthened between on-farm conservation and development. Future efforts to protect and conserve agricultural biodiversity must move from *ex situ* conservation to on-farm management of genetic resources.

Where's the Political Debate?

The Consultative Group on International Agricultural Research (CGIAR), established in 1971, is an informal association of public and private donors that supports a network of 16 international agricultural research centres (IARCs), each of which has its own governing body. The CGIAR Secretariat is housed in the World Bank (Washington, D.C.) and the Group's major donors include the World Bank, Japan, USA and The European Union. The CGIAR annual budget is about US$300 million. Currently, the CGIAR comprises

53 members, six of which are from the South. In 1996, the Group initiated an External System Review (The Third Review) which is currently underway. NGOs (including RAFI)have long been critical of the lack of intergovernmental control over the CGIAR's genebanks, and lobbied to establish the 1994 agreement between FAO and CGIAR which placed the germplasm in 12 IARC genebanks under the auspices of FAO. In addition, NGOs believe that farmers and scientists from the South to date have been severely under-represented in the governance of the CG. NGOs welcome the current NARS initiatives, strongly supported by IFAD and FAO, to rectify this situation and to become more actively involved in prioritising and implementing the CGIAR research agenda. The recent increases in developing country membership of the Technical Advisory Committee and in the IARC Boards of Governance is encouraging in this context.

International Plant Genetic Research Institute (IPGRI) is the CG institute with direct system-wide responsibility for germplasm. IPGRI has been one of the most constructive and progressive IARCs. They have worked closely with civil society organizations and other UN agencies on both technical and policy matters related to conservation and utilization of agricultural biodiversity. IPGRI, in close collaboration with FAO, plays a critical role in genetic resources conservation and in linking conservation and biodiversity to poverty alleviation and protection of the environment towards sustainable food security.

Notes

92 From a paper presented at the Annual Board Meeting of Agricultural Missions, Decorah, Iowa. May 13–16, 1995.

93 FAO. *State of the World's Plant Genetic Resources for Food and Agriculture*, Rome, 1996, p. 185.

94 RAFI Occasional Paper Series, "Declaring the Benefits," Vol. 1, No. 3, October, 1994.

95 Draft Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, 1996, Rome, p. 4.

96 All of the following examples are taken from FAO, *State of the World's Plant Genetic Resources for Food and Agriculture*, Rome, 1996, pp. 65–70.

97 All of the following information on types of collections comes from FAO, *State of the World's Plant Genetic Resources for Food and Agriculture*, Rome, 1996, p. 59–62.

98 *State of the World's Plant Genetic Resources for Food and Agriculture*, p. 60.

99 *State of the World's Plant Genetic Resources for Food and Agriculture*,, p. 62.

100 Draft Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture.

101 *State of the World's Plant Genetic Resources for Food and Agriculture*, p. 78.

102 *State of the World's Plant Genetic Resources for Food and Agriculture*, p. 75.

103 *State of the World's Plant Genetic Resources for Food and Agriculture*, p. 78.

104 *State of the World's Plant Genetic Resources for Food and Agriculture*, p. 79.

105 *State of the World's Plant Genetic Resources for Food and Agriculture*, p. 81.

106 Cited in *State of the World's Plant Genetic Resources for Food and Agriculture*, p. 74.

107 *State of the World's Plant Genetic Resources for Food and Agriculture*, p. 74.

108 Berg, Trygve, DRAFT.

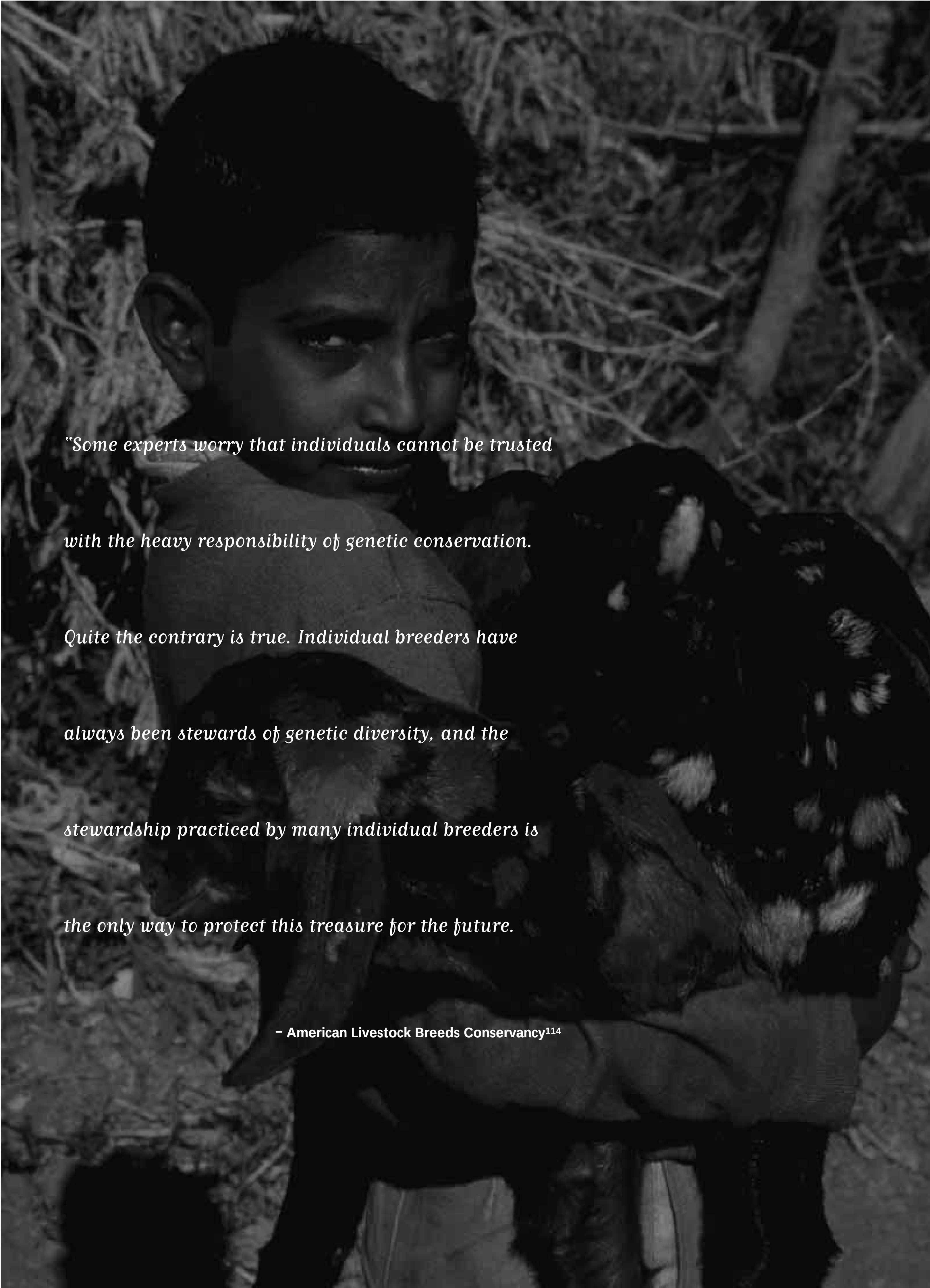
109 Draft Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture.

110 Keystone International Dialogue Series on Plant Genetic Resources, *Final Consensus Report: Global Initiative for the Security and Sustainable Use of Plant Genetic Resources*, 31 May–4 June, 1991.

111 Montecinos, C., "Bringing Farmer & Non-Farmer Breeders Together," *Seedling*, Vol. 11, No. 4 (1994), pp. 13–15.

112 Hernandez Bermejo, J.E., "*Evaluaciez Bermejo, J.E., "Evaluación de las colecciones ex situ conservadas en jardines botanicos"*, report prepared for FAO, 1995.

113 RAFI Communique, "Pharmaceutical Companies Bid for Northern Botanical Garden Collections in Attempt to Avoid the Biodiversity Convention," July/August 1996, pp. 1–6.



"Some experts worry that individuals cannot be trusted with the heavy responsibility of genetic conservation. Quite the contrary is true. Individual breeders have always been stewards of genetic diversity, and the stewardship practiced by many individual breeders is the only way to protect this treasure for the future.

– American Livestock Breeds Conservancy[114]

CHAPTER 5

FARM ANIMAL GENETIC RESOURCES

What is Domestic Animal Diversity?

Animal genetic resources include all species, breeds and strains that are of economic, scientific and cultural interest to humankind for agriculture, now and in the future. Of the 50,000 or so vertebrate species in the world today, only about 40 species of mammals and birds are widely recognized as domesticated species.[115] The major animal domesticates include seven mammalian species (asses, buffalo, cattle, goats, horses, pigs and sheep) and four avian species (chickens, ducks, geese and turkeys). These livestock species are used extensively throughout the world in almost all human cultures. Minor domesticated species are found in restricted locations, and though fewer in number, they are critically important to the people whose livelihoods are built around them. Examples are guinea pigs, alpacas, llamas, yaks, camels, elephants, musk oxen and reindeer.

Wild ancestral relatives of domestic livestock also make important contributions to food and agricultural production, and offer genetic potential for the future. The FAO has identified at least 35 species of animals and birds which are the wild relatives of domestic species.[116] Wild species can often thrive and produce in areas unsuitable for conventional domestic livestock. The term "wild" is often misleading; it does not necessarily refer to animals that are un-managed or un-improved by people. Some of these animals are found in the wild, others are farmed, and still others are bred in captivity. Many "wild" or semi-domesticated species, though scarcely recognized on an international level, contribute significantly to household food security. Examples include the African grasscutter, red jungle fowl of Southeast Asia, iguanas of Central America, capybara of South America, vicuna of the high Andes, and the caribou of northern Scandinavia, Russia and North America. (See box – The Value of Minor Domesticated Animals and their Wild Relatives.)

Most animals were first domesticated in the South; North America and Oceania have no indigenous mammalian livestock species.[117] The process of animal domestication began about 11,000 years ago in the Fertile Crescent of Southwest Asia between the Mediterranean Sea and the Persian Gulf. Goats and sheep were the first species to be domesticated for food. Pigs and cattle followed some 8,000 years ago, also in southwest Asia. Horses were domesticated about 6,400 years ago in central Eurasia; chickens were domesticated about 5,000 years ago in Southeast Asia; and buffalo were domesticated about 4,000 years ago in India and Southwest Asia. Alpacas and llamas were domesticated in the Andes mountains some 6,000 years ago. Turkeys were first domesticated in Central and South America about 2,000 years ago.[118]

Though the number of domesticated animal species is small, their impact has been enormous. According to FAO, domestic animal species provide an estimated 30–40 percent of the value of all food and agriculture production worldwide.[119] An estimated 1.97 billion

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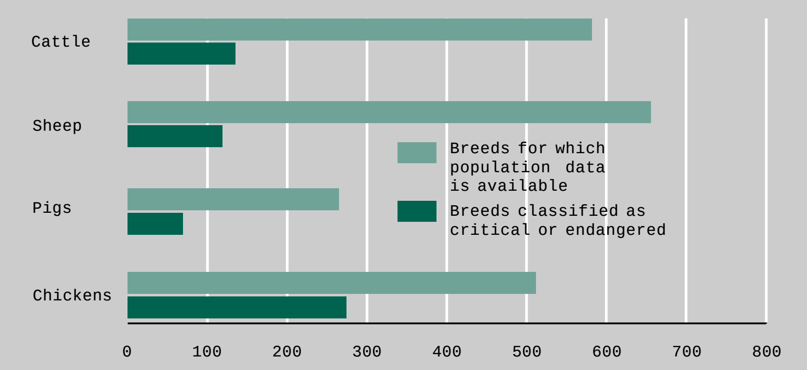
Domestic animal diversity at risk



people – or one-third of the world's population – depend on livestock for some portion of their livelihood.[120] Animals account for about 20% of the world's food basket directly, but they also contribute draught power and fertilizer for crop production, and provide a valuable form of cash reserves in many mixed farming systems. Livestock process forage and crop waste, inedible by humans, into nutritionally important food products. In addition to food, people have selected animals for a wide range of services and products for both subsistence and income. Livestock provide fibre, draught work, means of transport, pest control, companionship and products such as hides, wool, tallow, bone and manure.

Why is Domestic Animal Diversity Important?

Centuries of human and natural selection have resulted in thousands of genetically diverse breeds within the major livestock species.[121] Over the past 11,000 years these breeds were carefully selected and nurtured by thousands of cultures to fit a wide range of environmental conditions, tasks and human needs. The rich genetic legacy we have inherited from our farming ancestors is a vast array of animal breeds, each characterized by its unique adaptive and productive traits. Some livestock and poultry breeds are resistant to parasites or disease, for example, while others are adapted to humidity, or drought or extremes of hot and cold. Domestic animal diversity, represented by this wide range of breeds, is essential to sustain and enhance the productivity of agriculture.

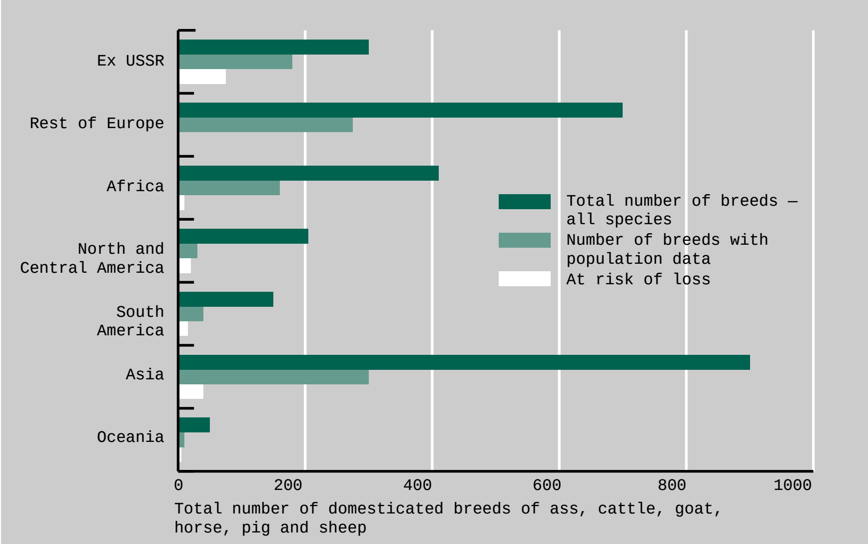
The genetic diversity found in domestic animal breeds allows farmers to select stock or develop new characteristics or breeds in response to changes in the environment, threats of disease, market conditions and societal needs, all of which are largely unpredictable. Breeds which are rare today may carry traits which will be of commercial importance in the future. The Finn sheep, for example, was cast aside by commercial breeders decades ago and kept only by Finnish peasants. Today the Finn's fecundity – its ability to produce litters of lambs instead of singles or twins – is widely utilized in the sheep industry.[122] The rare

Domestic Animal Biodiversity and Economic Opportunity

Animal genetic resources are exchanged and exploited worldwide to improve the characteristics and productivity of animals, and to develop new breeds. The following examples illustrate the immediate and long-term economic potential resulting from breed conservation, as well as the importance of access to and exchange of genetic resources among all nations of the world.

- The Sahiwal dairy breed of cattle, from Pakistan, was introduced into Australia to confer tick resistance on Friesian herds.[143]
- West African N'Dama cattle have been crossed with the Red Poll, an endangered British breed, to produce the Senepol breed, which has been introduced

Domesticated animals at risk



A great variety of breeds has been developed since domestication, particularly in Europe and Asia, but many are now threatened with extinction.

Taihu pigs of China offer valuable traits for swine breeders worldwide. These pigs can use a high proportion of forage foods in their diet. In addition, they reach sexual maturity in just 64 days and are extraordinarily fertile, producing an average litter of 16 piglets compared to only ten for Western breeds.

Indigenous livestock breeds often possess valuable traits such as disease resistance, high fertility, good maternal qualities, longevity, and adaptability to harsh conditions and poor-quality feeds, all qualities that form the basis for low-input, sustainable agriculture. The Fayoumi chicken of Egypt, for instance, is an indigenous breed that goes back to the time of the Pharaohs. It is a good egg layer, capable of withstanding high heat conditions and is also resistant to several poultry diseases.[123]

Rare breeds often possess unique traits of special significance to local people and economies. The Navajo-Churro sheep of the southwestern United States, for example, is valued by Native Americans who use its strong and resilient carpet wool for weaving traditional rugs that are recognized internationally for their beauty and distinctive designs.[124] The rare breed of Reggina cattle found in northern Italy is especially valued for its milk which produces high-quality Parmesan cheese.[125]

Indigenous breeds in some regions of the world can survive where newer breeds would perish. The small humpless N'Dama cattle have long been maintained by West African farmers in marginal farming areas. These cattle have developed resistance (trypanotolerance) over thousands of years to a deadly disease transmitted by the tsetse fly – a trait that relatively "modern" African breeds do not possess. Though less productive than industrial

successfully in the Caribbean and in the Southern United States.[144]

- Dairy cattle from Europe and North America have been crossbred with the Zebu cattle of India and South America to increase milk yields.[145]
- Using the rare Meishan pig of China, breeders in the United Kingdom have produced a commercial hybrid that combines the fecundity of the traditional Chinese breed with higher lean meat content.[146]

breeds, the N'Damas' disease resistance, hardiness and longevity make these cattle extremely valuable in harsh environments.

The gradual disappearance of indigenous breeds that are able to survive in extreme environments, such as deserts or other uncultivatable lands, undermines food and livelihood security for the poor, and the capacity of people to survive in marginal areas of the world. Approximately 40% of the total land available in developing countries can only be used for some form of forage production.[126] An estimated 12% of the world's population lives in areas where people depend almost entirely on products obtained from ruminant livestock – cattle, sheep and goats.[127] Farmers and pastoralists in many areas of the world not only contribute significantly to the maintenance of biodiversity in domesticated animals, they also help keep otherwise barren tracts of land available for human habitation.[128] For these farmers, an animal's most essential quality is not its rate of growth or yield of milk, but its basic ability to survive and reproduce, which in turn ensures the family's self-reliance and survival.[129]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Vanishing Breeds

No major livestock or poultry species is in danger of extinction, but numerous breeds within those species are declining in population and size, and many have already disappeared. In Europe, half of all breeds of domestic animals that existed at the turn of the century have become extinct, and 43 percent of the remaining breeds are endangered.[130] The 1995 edition of FAO's "World Watch List for Domestic Animal Diversity" includes data on 3,882 breeds for 28 domestic species. It concludes that globally 30% of breeds are classified as endangered and critical.[131]

The Value of Minor Domestic Animal Species and Their "Wild" Relatives

- More than 73 million guinea fowl, a semi-domesticated producer of meat and eggs, are kept by village farmers in the dry regions of West Africa.
- In Peru, 20 million domestic guinea pigs produce annually between 16,000–17,000 tons of meat. It is estimated that 20 females and 2 males can produce enough meat year round to provide an adequate protein diet for a family of six.[147]
- The capybara is the world's largest rodent and is as big as a sheep. The species is widely eaten in South America; more than 500 tons of meat are sold per annum in Venezuela alone. The capybara is also valued for its hide, as a source of rennet for

The status of livestock breeds in Europe and North America is better known and documented, while relatively little is known about animal diversity in the South.[132] Yet it is in this region where many of the more unusual and best-adapted animals are found today.[133] It is also where breeds are in greatest danger of genetic erosion. Unfortunately, the lack of data from those regions containing the greatest diversity, gives us an incomplete and distorted picture of the status and trends of domestic animals breeds worldwide. By all accounts, however, the rate of breed extinction has accelerated dramatically over the past 100 years. When a breed becomes extinct, an already narrow genetic base shrinks irreversibly.

Among the critically endangered animal breeds identified by FAO are the North Ronaldsay sheep of the Orkney Islands off Northern Scotland that survive exclusively on a diet of seaweed; the Yakut cattle of Northern Siberia that withstand extreme fluctuations of temperature with little management; the Olkuska sheep native to southern Poland that are exceptionally prolific and sometimes produce litters of five or six lambs; the Javanese Zebu cattle that are highly fertile, hardy and resistant to tick infestation.[134] These are just a few examples of breeds under threat of extinction.

A 1994 North American livestock census, prepared by the U.S.-based, non-governmental organization, American Livestock Breed Conservancy (ALBC), finds rapid genetic erosion in all livestock species of North America.[135] Of 200 breeds of asses, cattle, goats, horses, sheep and pigs examined, nearly 80 breeds are in decline or in danger of extinction. Among the critically endangered breeds is the Gulf Coast Native sheep, a sheep that shows remarkable genetic parasite resistance, and adaptation to the high heat and humidity of their native habitat.[136] The rare American Mammoth Jackstock, unique to North America, is described by ALBC as "one of the finest mule-producing ass breeds in the world," but its numbers have dropped to only a few hundred as draught animals in agriculture have been replaced by machines.[137]

Why Are We Losing Animal Genetic Diversity?

Worldwide, the greatest threat to domestic animal diversity is the highly specialized nature of industrial livestock production. In the industrialized world, commercial livestock farming is based on very few breeds or strains that have been selected for the intensive production of meat, milk or eggs in highly controlled and regulated conditions. The spread of industrial agriculture in the South places thousands of native breeds at risk from genetic dilution or replacement by imported stocks. Commercial breeds imported from North America and western Europe are usually unable to sustain high production in less hospitable environments. They require intensive management and costly inputs such as high-protein feed, medication, and climate-controlled housing. Introduction of intensive animal production in most areas of the South creates dependency on imported technologies and germplasm; it is neither affordable nor sustainable for poor farmers.

The common approach of importing exotic animal breeds to boost productivity of livestock in the South is now being rethought in recognition of the fact that native breeds

making cheese and for oil extracted from its fat.

- The wild grasscutter or cane rat is an important source of protein throughout Subsahelian Africa. In Accra, Ghana during one year, 73 tons of bushmeat from the grasscutter were sold in one local market.
- The endangered Asian elephant is both domesticated and found in the wild. Trained elephants are used in many Asian countries for selective felling of timber, greatly reducing the environmental damage caused by heavy machinery. In Thailand, a 20-year old trained elephant costs about US$6,000 and has a working life of 30 years. By comparison, a crawler tractor costs US$100,000, has a working life of six years, and requires costly maintenance, and imported fossil fuels.[148]

Biological monopolies?

Corporate Concentration in Industrial Breeding Stock

The Example of Poultry

TURKEYS: 3 multinational breeders supply world market
Booker, plc (UK) *owns Nicholas Turkey Breeding Farms*
Merck & Co. (USA) *owns Hubbard Farms and British United Turkeys*
Nutreco (Netherlands) *owns Hybrid Turkeys Inc.*

EGGS: 5 multinational breeders supply world egg market
Lohmann Tierzucht GmbH(Germany) *— owns Hy-Line and H&N, #1 white egg breeder in the world*
ISA (French) *— owns Shaver and Babcock*
Toshoku Ltd. (Japan) *— owns Dekalb Poultry*
Euribrid B.V. (Netherlands) *— owns Hi-Sex*
Hendrix Breeders (Netherlands) *— owns Bovans*

BROILERS: 6 multinational breeders dominate world broiler market
Merck, Inc. (USA) *Hubbard Farms*
Booker PLC (UK) *Arbor Acres*
Hillsdown Holdings plc (UK) *Ross Breeders*
Tyson Foods (USA) *Cobb*
CP Group (Thailand) *Avian Farms Intl.*
Peterson Breeders (USA)

SOURCE: *RAFI — compiled from interviews and industry sources*

are far more likely to be productive under low-input conditions. Many native breeds have great potential for increase of production without loss of local adaptation, which can be realized with appropriate selection programmes.[138] According to Keith Hammond, FAO expert on animal genetics, "In 80% of the world's rural areas the locally adapted genetic resources are superior to common modern breeds."[139]

Industrial stocks alone are not an adequate genetic reservoir for the future. These stocks rest on a narrow genetic base which has been selected solely for maximizing production. The commercial white turkey that is mass-produced on factory farms in North America and Europe, for example, has been selected for such a meaty breast that it is no longer able to breed on its own. This broad-breasted breed – which accounts for 99% of all turkeys in the United States today – would become extinct in one generation without human assistance in the form of artificial insemination.[140]

Intensive livestock production in the North is characterized not only by genetic uniformity, but also by increasing consolidation in control and ownership of industrial breeding stock. In the poultry industry, for example, 5 industrial breeders, all owned by transnational corporations, dominate the world industrial egg market. Six transnational breeders dominate the world industrial broiler market and just three corporate breeders supply the

Mammalian Cloning

In February, 1997 the Scottish-based Roslin Institute stunned the scientific world and ignited worldwide ethical debate when it announced that it had produced a lamb named Dolly, the first cloned mammal. Dolly is living proof that viable offspring can be developed from a single adult cell.

After Dolly came Polly. In July, 1997 the Roslin Institute announced that it had achieved another "world first" with Polly, a cloned lamb which carries human genes. The significance of the breakthrough is that researchers are now poised to produce "instant flocks" of genetically engineered animals that can efficiently produce valuable human therapeutic proteins in their milk, such as blood clotting proteins for hemophiliacs, or insulin for diabetics. Once genetically engineered animals can be cloned routinely, it will mean faster and more uniform production of profitable proteins. According to industry analysts, the market for therpeutic proteins is currently about US$7.6 billion per annum, and is world's turkey market. (See table, "Biological Monopolies" for a list of these industrial breeders.) The genetic base for industrial poultry is described by Canadian poultry geneticist Roy Crawford as "exceedingly narrow" and "vulnerable to genetic disaster."[141] Ironically, it is the unparalleled productivity and success of these industrial stocks that is indirectly responsible for most of the erosion and loss of poultry genetic resources worldwide.

New animal reproduction technologies also play a role in depleting diversity because techniques such as artificial insemination, multiple ovulation, *in vitro* fertilization and embryo transfer are capable of producing large numbers of genetically uniform offspring from only a few parents. As fewer and fewer animals are used for breeding, a breed's genetic base is narrowed with every generation. The rapid and widespread introduction of exotic germplasm to all areas of the world is facilitated by reproductive technologies because shipment of semen, ova or embryos is far more practical and less expensive than transporting live animals across continents and oceans. Even well-meaning foreign aid programmes that donate imported animal semen to the developing world, for example, have been cited as agents of extinction for many indigenous breeds, particularly cattle.[142] It is important to note, however, that these same technologies, if properly used, can be valuable tools for genetic resource management and conservation.

Conserving Domestic Animal Diversity

Like plants, animal genetic resources can be conserved both *in situ* and *ex situ*. *Ex situ* involves the preservation of animals in a setting removed from their normal habitat. It includes "cryogenic preservation techniques" – the collection and freezing in liquid nitrogen of animal genetic resources in the form of living semen, ova or embryos, or the preservation of DNA segments in frozen blood or other tissues. *Ex situ* conservation also includes the captive breeding of wild or domesticated species in zoos or other situations removed from their indigenous environment. *Ex situ* conservation complements conservation of live populations and provides a safeguard when population numbers are dangerously low. Despite the potential of new molecular technologies, however, scientists are not yet able to artificially re-create extinct animal breeds from bits and pieces of frozen DNA.

The genetic diversity of livestock can only evolve in use – and only in use can it retain its value for future generations. *In situ* conservation enables animal populations to continue to adapt, evolve and be selected for use in their natural environments. Unlike cryogenic techniques which require technology, equipment, knowledge and training for collection and storage, *in situ* conservation can be carried out at any level, in any country, with the skills and resources already available. *In situ* livestock conservation programmes are currently administered by national governments, by non-governmental organizations, by cooperative groups of farmers and by individuals.

expected to grow to US$18.5 billion by 2000.

Another potential and highly profitable use of transgenic, cloned livestock is the assembly line production of "spare-part" animal organs for human transplant. Pig clones, for example, could be genetically engineered to be a source of replacement organs for humans. There is a huge potential market in replacement organs from transgenic animals. The immediate market need for transplant organs is estimated to be US$6 billion.

The cloning breakthrough raises many moral and ethical issues, including concerns relating to the loss of livestock genetic diversity. Proponents of livestock cloning are quick to point out that the technique will give us the tools we need to rescue endangered livestock breeds. In theory, yes. But these are patented technologies that will be applied primarily to industrial livestock breeds. Rather than becoming tools for conerving and using greater diversity, it is more likely that cloning will exacerbate the problem of genetic uniformity.

The cloning of mammals may jeopardize livestock diversity if we are persuaded that technology can "save" diversity. No matter how skilled we become in cloning cells, transferring embryos or designing transgenic livestock, we can't "create" diversity once it's gone. Extinction is still forever.

While *ex situ* conservation will always play a vital complementary role in preserving animal genetic resources, it will never be an adequate substitute for rural communities who conserve and use livestock genetic resources on a daily basis. Throughout history, agriculture has been shaped by the genius and innovation of millions of livestock breeders dispersed far and wide. In recent decades the spread of industrial livestock production has not only eroded livestock diversity – it has also reduced the number of *breeders, conservers* and *users* of animal genetic resources. These trends do not bode well for conservation of livestock biodiversity. People and domestic animals have been linked over centuries of co-evolution and inter-dependence, and this partnership is key to the future conservation and use of animal genetic resources, particularly in the South. Both *in situ* and on-farm conservation and use of animal breeds must play an increasingly important role in the future of genetic resource conservation. Ultimately, conservation of domestic animal diversity depends on the diversity of human cultures, environments and production systems that helped to shape them over millennia.

Farm Animal Genetic Resources – Where's the Political Debate?

The United Nations Conference on Environment and Development (UNCED), its Biodiversity Convention and Agenda 21, were the catalyst for formally identifying domestic animal diversity as a genuine and important component of global biodiversity. FAO has been recognized as the most appropriate inter-governmental body to implement a global programme for the conservation and management of farm animal genetic resources.

FAO's "Global Programme for the Management of Farm Animal Genetic Resources" was launched in 1992. It aims to:

1) Identify, monitor and characterize domestic animal diversity;
2) use and develop animal genetic resources to promote productivity and sustainability in agriculture worldwide;
3) manage genetic resources to assure long term availability;
4) train and involve people in management and use of animal genetic resources;
5) communicate to the world community the importance of diversity in domestic animals and their wild relatives.

With the support of the UN Environment Programme and the European Association of Animal Production, FAO has initiated a global inventory and basic description of domestic livestock breeds worldwide. As of mid-1995, the global databank listed 3,882 breeds for 28 domestic species, to be used as a "Global Early Warning System for Animal Genetic Resources."

Issues of Ownership and Control: Under the *Convention on Biological Diversity* (CBD) States have sovereign rights over their genetic resources and authority to determine who may have access to them. But there is no farm animal genetic resource equivalent to the FAO Undertaking on Plant Genetic Resources. Given the growing importance of the intenational transfer and exchange of animal genetic resources, it is important that intergovernmental mechanisms incorporating farm animal genetic resources be designed to protect farmers' rights and to ensure access and exchange consistent with other genetic resources for food and agriculture under the constitutional umbrella of the CBD. It is imperative that farm animal genetic resources be included as part of a possible protocol to the CBD on agricultural biodiversity.

The International Livestock Research Institute (ILRI), based in Kenya and Ethiopia, is the international agricultural research centre under the Consultative Group on International Agricultural Research (CGIAR) that specializes in livestock research, focusing on ruminants. The CGIAR is now examining how it can best coordinate and develop its animal genetic resources activity under FAO's global strategy.

Notes

114 Sponenberg, D. Phillip and Carolyn J. Christman, *A Conservation Breeding Handbook*, American Livestock Breeds Conservancy (ALBC), Pittsboro, NC (US), 1995, p. 2.

115 Global Biodiversity Assessment, p. 129.

116 Scherf, Beate D., ed., *World Watch List for Domestic Animal Diversity* (2nd Edition), FAO, Rome, September 1995, pp. 18–20.

117 Mason, Ian L. and Roy D. Crawford, "Global Status of Livestock and Poultry Species," Appendix A, in *Global Genetic Resources: Livestock*, p. 143. This does not mean that North American and Oceania do not have important animal breeds. Many populations can be identified that are unique to these areas and require conservation efforts.

118 Information about origins of domesticated animal species found in *Managing Global Genetic Resources: Livestock*, p. 22.

119 Hammond, Keith and H.W. Leitch, "The FAO Global Program for the Management of Farm Animal Genetic Resources, paper presented at: "Biotechnology's Role in the Genetic Improvement of Farm Animals", Beltsville, MD, (US), May 14–17, 1995, p. 2.

120 According to Keith Hammond of FAO this estimate is based on the number of people economically active in agriculture and estimate of farm units incorporating livestock. Personal communication with Keith Hammond, FAO, August, 1996.

121 A breed is a group of animals that can be readily distinguished from other members of the species by some identifiable common appearance, performance, ancestry, selection history, adaptation or other feature.

122 Bixby, Donald E et al. *Taking Stock: The North American Livestock Census*, McDonald & Woodward, Blacksburg (US), 1994, p. 21.

123 Personal communication from David E. Steane, Animal Production Officer, FAO, 3 March 1993.

124 *Taking Stock*, p. 84.

125 FAO Press Release, "FAO Releases First World Watch List for Domestic Animal Diversity", 19 November 1993, p. 2.

126 National Research Council, *Microlivestock*, National Academy Press, Washington, 1991, p. 6.

127 *Microlivestock*, p. 6.

128 Kohler-Rollefson, Ilse, p. 14–16.

129 Brochure entitled, "The Genetics of Disease Resistance in Tropical Livestock," produced by the International Livestock Research Institute, nd, p. 2.

130 FAO Press Release, 28 January 1992, "Livestock Breeds in Developing World Threatened,"p. 1. See also FAO Press Release, 5 December 1995, "New FAO World Watch List for Domestic Animal Diversity Warns: Up to 1,500 Breeds Are at Risk of Extinction," p. 2.

131 Hammond, Keith and H.W. Leitch, "The FAO Global Program for the Management of Farm Animal Genetic Resources", p. 5. FAO defines endangered as populations having < 1000 breeding females and < 20 breeding males. Critical populations have < 100 breeding females and < 5 breeding males.

132 *Managing Global Genetic Resources: Livestock*, p. 13.

133 Mason, Ian L. and Roy D. Crawford in *Global Genetic Resources: Livestock*, p. 142.

134 FAO press release, "FAO Releases First World Watch List for Domestic Animal Diversity", 19 November 1993, p. 2.

135 *Taking Stock*, p. 107.

136 *Taking Stock*, p. 20.

137 *Taking Stock*, p. 32.

138 Hall, Stephen J.G. and Daniel G. Bradley, "Conserving Livestock Breed Biodiversity," *TREE*, Vol. 10, No. 7 (July 1995), p. 267.

139 FAO Press Release, 5 December 1995, "New FAO World Watch List for Domestic Animal Diversity Warns: Up to 1,500 Breeds Are at Risk of Extinction," p. 2.

140 *A Conservation Breeding Handbook* , p. 20.

141 Crawford, R.D., "Poultry Conservation: The International Situation," unpublished paper, nd. See also, Ian L. Mason and Roy D. Crawford in *Global Genetic Resources: Livestock*, p. 163–4.

142 Hall, Stephen J.G. and John Ruane, "Livestock Breeds and Their Conservation: A Global Overview," *Conservation Biology*, Vol. 7, Number 4 (December 1993), p. 823.

143 *Global Biodiversity Assessment*, p. 465.

144 Personal communication with Donald E. Bixby, Executive Director of ALBC, March 1993.

145 Global Biodiversity Assessment, p. 465.

146 Shand, Hope, "Harvesting Nature's Diversity," document for FAO World Food Day, 1993, p. 11.

147 Scherf, Beate D., ed. *World Watch List for Domestic Animal Diversity, 2nd Edition*, FAO, Rome, September 1995, p. 703.

148 *World Watch List for Domestic Animal Diversity, 2nd Edition*, p. 691.

"In the end, the fate of the earth's wooded lands is tied to the fate of their inhabitants. They will rise or fall together. Either rights to ancestral lands will be defended with the full force of the law, or the forest will fall. Either they will be accorded a share of the economic worth of the ecological services their forests provide, or the forests will fall. Either they will be allowed into the corridors of power where policies are made, or the forests will fall. Other things can help save forests, but these things are fundamental. Tenure, price, and power."

– Alan Thein Durning[149]

CHAPTER 6

FORESTS

Forested areas of the world today cover approximately 3,442 million hectares, 27 percent of the earth's area.[150] Forests are the most species-diverse terrestrial habitats.[151] At the end of 1990, approximately 51% of the world's forests were located in the tropics and sub-tropics.[152] Tropical forests, both moist and dry, cover an estimated 1,756 million hectares in frost-free regions between the Tropic of Cancer and the Tropic of Capricorn.[153]

Tropical forests comprise the most complex, species-rich ecosystems in the terrestrial world. Fourteen of the 18 areas on Earth with unusually high plant endemism (that is, plants found nowhere else) lie within the *moist* tropics. These forests collectively contain more than 37,000 endemic species, or 15% of all plant species, in less than 311,000 sq. km., or just 0.2% of the Earth's land surface.[154]

In Amazonian Ecuador, 473 tree species have been recorded on a single hectare. In Panama, 1200 species of beetles have been collected on a single tree species.[155] Despite these impressive statistics, current knowledge of tropical forest diversity is shockingly incomplete. In the supposedly well-inventoried region of Iquitos, Peru, nearly 70% of extracted timber comes from a tree species first recognized by Western science in 1976.[156] Estimates of the proportion of tropical insect species still not described range from a low of 65% to a high of 99%.[157] Although mammals are one of the best known groups of organisms, a new genus of bovid, Pseudoryx, possibly related to oxen, was discovered in remote forests of Vietnam in 1992.[158]

Forests: Food and Livelihood Security for People

Nobody knows exactly how many people live in or depend on forests in the South. According to FAO, forests are home for an estimated 300 million people – shifting cultivators and hunter-gatherers – around the world. But country-specific estimates compiled by NGOs suggest that the global population of peoples living in or dependent on forest resources has been drastically under-counted in the past. In six Southeast Asian countries alone (India, Indonesia, Nepal, Philippines, Sri Lanka, Thailand) the forest-dependent population exceeds 600 million according to NGO estimates.[159]

Food security, income, nutrition, employment, energy sources and overall well-being of rural people are linked to the forests. Rural people living in and around forests depend on a large variety of forest products for subsistence and income, including foods and spices, building materials, medicines, fibres, fodder, resins, oils, latex and industrial materials. A new study by scientists from Cornell University (New York, USA) conservatively estimates that the value of non-timber products harvested from tropical forests is $90,000 million per annum.[160] When forest ecosystems are degraded, and when local people lose

CIDA PHOTO: PIERRE ST. JACQUES

access to forest resources, the livelihood and survival of millions of forest-dependent people is at stake.

Benefits and Use of Forests

Forest benefits and services go far beyond timber. Food and fodder from forests is a major contributor to household food security in the South. Forest foods – from both "wild" and domesticated species – include leaves, seeds and nuts, fruit, honey, roots and tubers, saps and gums, fungi and animals. In wooded areas of Thailand, for example, 60 percent of all food comes directly from the forests. In the Upper Shaba area of Zaire, local people gather and consume more than 20 tonnes of forest mushrooms per annum, an important source of protein and minerals.[161] In Nigeria, people living near forests consume over 84% of their animal protein from forest game.[162]

The link between forests, biodiversity and food security is made abundantly clear in FAO's 1996 Report on the State of the World's Plant Genetic Resources for Food and Agriculture. In Africa, the most frequently cited cause of genetic erosion is destruction of forest and bush lands.[163] Most Latin American countries providing data also report "major genetic erosion" of economically important forest species.[164] Worldwide, forests harbor genetic resources of plants, animals and microorganisms that provide the raw material for genetic improvement in crops and livestock. For example, the wild relatives of avocado, banana, cashew, cacao, cinnamon, coconut, coffee, grapefruit, lemon, paprika, oil palm, rubber and vanilla are found in tropical forests.[165] Export products from these crops were

CIDA PHOTO: PAT MORROW

valued at over $23,000 million in 1994.[166] Red jungle fowl, ancestors of the domestic chicken, are found in the hottest and most humid forests of Asia. The genetic variability contained in red jungle fowl is considered one of the most important sources of genetic diversity for domestic chicken breeds – whose genetic base is extremely narrow.[167]

Worldwide, forests and forest industries provide wood products valued at over US$400,000 million per annum (including timber, furniture, pulp and paper, and fuelwood).[168] Following timber, rattans are the second most important source of export earnings from tropical forests, accounting for more than US$1,000 million annually.[169] Approximately 90% of the rattan used commercially comes from the "wild." Of the 104 species of rattan found in the Malay Peninsula alone, 98 are threatened or endangered.[170]

Three-quarters or more of the South's population depend on woody species as their primary energy source. Because so many people depend on fuelwood to prepare, process and preserve food, there is an implicit relationship between fuelwood and food security.

Fuelwood accounts for 58 percent of energy use in Africa, 15 percent in Latin America and 11 percent in Asia.[171] An estimated 100 million people in the South cannot get sufficient fuel to meet energy needs and almost 1.3 billion are consuming fuelwood faster than it is being replenished.[172] The demand for firewood is not just in rural areas; urban and industrial consumption of fuelwood and charcoal are also major factors in forest degradation and deforestation.[173]

Forests provide vital ecological functions. Their absorption of carbon dioxide and release of oxygen through photosynthesis help to control the level of greenhouse gases. This process, in turn, helps moderate fluctuations in global temperatures and provides the atmospheric elements essential for all living things. The widespread conversion of forested ecosystems in the South to grasssland and pasture contributes to the increase in atmospheric carbon dioxide and the build-up of greenhouse gases. During the 1980s, conversion of tropical forest to grassland contributed approximately 1.6 gigatons of carbon per year to the atmosphere. This is equivalent to about 16% of the carbon emissions released by the global consumption of fossil fuels for industry and transport, currently estimated at 5.5 gigatons of carbon per year.[174]

Forest vegetation helps support the resource base by nutrient cycling. Forests keep soil from eroding into rivers and aid in flood control and the prevention of silting of reservoirs. An estimated 40 percent of the South's farmers depend on forested watersheds as a source of water for irrigating crops or watering livestock.[175]

Many forest species, their potential use to society, and their ecological importance have yet to be discovered. Untapped treasures contained in the genes of forest-dwelling plants, animals and microorganisms include undeveloped medicines, crops, animals, pharmaceuticals, timbers, fibers, pulp, soil-restoring vegetation, petroleum substitutes and countless other products and amenities. The bark of the rare western yew tree *(Taxus brevifolia)*, found only in the old-growth coniferous forest of the Pacific northwestern United States, was recently found to be the source of taxol, a potent anticancer chemical. The US National Cancer Institute recently discovered a promising anti-AIDS drug, michellamine B, that comes from a rainforest vine collected in Southwestern Cameroon.[176] If forest felling continues at its present rate, and if reservoirs of traditional knowledge continue to be lost, new and existing sources of scientific information will be forfeited and vast potential biological wealth will be destroyed.

World Forest Decline

The world's forests are being destroyed at unprecedented rates. Major threats to forest genetic resources are deforestation and atmospheric pollution.[177] A third threat is the narrowing of the genetic base of tree species as a result of commercial forestry operations. According to FAO data from 1985, more than 400 temperate and tropical tree species are endangered in whole or in significant parts of their gene pools.[178] One cause of genetic erosion of forest tree species is the intensive breeding of a few economically important species in the absence of conservation programs. In the face of rapid environmental change, the future productivity of forests depends on conserving and using the genetic resources of trees.

Tropical Forests

FAO reports that between 1980 and 1990, tropical forest areas have been shrinking by an average of 15.4 million hectares per year. This is an annual loss of about 0.8%;[179] and a total loss over the decade of an area the size of Peru and Ecuador combined. Six countries – Brazil, Indonesia, Zaire, Mexico, Bolivia and Venezuela, accounted for about half of all tropical deforestation.[180]

The causes of tropical deforestation vary from region to region. The primary activities associated with deforestation include: the permanent conversion of forest land to agricultural use; harvesting of fuelwood and charcoal; commercial logging; dams; oil and mining projects; shifting cultivation; expansion of urban and industrial areas; overgrazing and fodder collection.

Although small farmers are frequently blamed as the leading causes of tropical deforestation, it is increasingly recognized that shifting cultivation systems as traditionally practiced by forest-dwelling people in the South are not only sustainable, they also actively

CIDA PHOTO: ROGER LEMOYNE

encourage diversity.[181] A study of shifting cultivators in Southeast Asia, Africa and the Amazon prepared by FAO in 1991 concludes:

"Shifting cultivation is a complex agricultural system that is well-adapted, under certain conditions, to the environmental limitations of the tropics. It is not primitive, nor necessarily destructive. It requires in-depth knowledge of the tropical environment and a high degree of managerial skill to succeed."[182]

Today, poverty, land use patterns and population pressures are reducing the land available for shifting cultivation. Shorter fallow periods and overuse of available land are turning traditionally sustainable methods into destructive ones. It is more often the newly arrived migrants, poor and landless people without generations of traditional knowledge, who are driven to over-exploit forest resources.[183]

Conversion of forests to agriculture – primarily by small-scale, subsistence farmers – is frequently cited as the single greatest cause of forest destruction in the South.[184] The Consultative Group on International Agricultural Research (CGIAR), in a 1996 press release, reported that "Poor farmers could destroy half of [the] remaining tropical forest.[185] Whether they are victims of unjust land tenure systems, refugees from political or social unrest, or settlers from poorly-conceived development programmes, poverty and the lack of access to land and jobs are the underlying causes of deforestation linked to poor farmers. Government policies in both the South and North are often at the root of these problems. Examples include subsidies to cattle-ranching and timber industries; agricultural development and colonisation policies that encourage clearing of forests; tax incentives for land development that lead to concentration of land ownership; under-valuation of forest resources and the people who inhabit them; lack of legal recognition for indigenous peoples land rights.

From 1980–1990, commercial logging for international and domestic consumption increased in Africa, Asia and Latin America – with a rise in both area and volume harvested. According to FAO, 5.9 million hectares were logged annually in the tropics from 1986–1990, with 83% of the cutting in primary forests.[186] While many believe that commercial timber can be harvested "sustainably," the evidence is hard to find. When the International Tropical Timber Organization conducted a study of "sustainable timber production" in 1988, it succeeded in identifying only 1 million hectares – or 0.12% of all timber producing tropical forests – that met their definition.[187] FAO claims that "little progress has been made in the sustainable management of natural forests."[188] Logging is only one of the causes of forest destruction, but its impact is magnified because it opens up the forest to further encroachment, and because most logging takes place in primary, species-rich forests.[189] Logging roads allow both displaced people and extractive industries to enter previously inaccessible forest areas.

Evidence from the Brazilian Amazon and West Africa suggest that the loss of biodiversity in forest ecosystems far exceeds the deforested area. Degradation and fragmentation of forests magnifies the destructive impacts of deforestation.[190] "Fragmentation" refers to patches of forest that are not deforested, but are too small to support remaining populations of plants and animals. Forest edges are particularly vulnerable to degradation. Because of the so-called "edge effect" the negative effects of deforestation extend approximately 1 km. into adjacent habitats. A 1993 study based on satellite imagery of the Brazilian Amazon found that the rate of deforestation averaged about 15,000 sq. km. per year from 1978–1988, while the rate of habitat fragmentation and degradation was about 38,000 sq. km per annum.[191]

Temperate and Boreal Forests

The loss of forest genetic resources is not confined to the tropics. Temperate and boreal forests account for almost half of global forest cover, but because they contain less biological diversity than tropical forests, they generally receive less attention. Boreal forests of northern Europe, Siberia and Canada cover 17% of the planet's land surface. FAO data show a net increase in forest area in Europe and the former USSR from 1980–1990. Although temperate and boreal forests are generally considered "stable," this description masks the rapid disappearance of old-growth stands, and the forest degradation occuring in some regions. Old growth forests are among the richest habitats found in temperate areas. In some cases, the rate at which they are disappearing exceeds the rate of forest deforestation in many tropical countries.[192] In Western Europe, old growth forests now account for less than 1% of total forest area. Among temperate countries only Canada and New Zealand hold more than 20% of their total forest area as old growth forests.[193] In Europe and North America, pollution from industrial and transportation activities and wildfires have threatened forests and the genetic resources of a range of species. Forests in Germany and Czechoslovakia, in particular, have been severely affected.

The effects of global warming could be catastrophic for forests, especially in higher latitudes. According to WWF International, even a 1 degree C absolute change in temperature could eradicate 25% of the world's boreal forests.[194] Tree species found in both temperate and boreal forests have slow migration rates and thus have limited ability to adapt to new climatic zones. Scientists predict that higher temperatures and drought caused by global warming will trigger forest fires and invasions of pests and diseases, thus accelerating the loss of forest biodiversity. A 2 degree C increase in temperature, for instance, would quadruple the area of forest in Bristish Columbia (Canada) that is susceptible to attack by spruce weevil.[195]

Tree Plantations

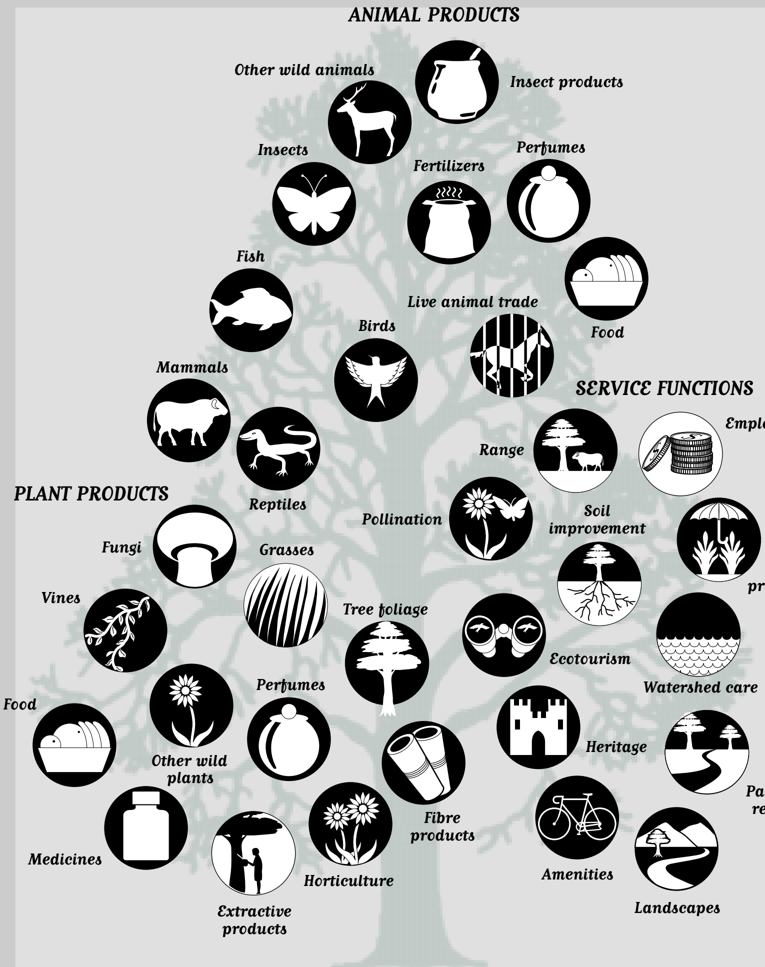
Worldwide, an estimated 100–135 million hectares are now devoted to tree plantations. The FAO estimates that at the end of 1990 there were 43.8 million hectares of industrial and nonindustrial forest plantations in the South.[196] The largest share, 73%, is found in the regions of tropical Asia and the Pacific. Just five countries – India, Indonesia, Brazil, Vietnam, and Thailand – account for 85% of all tropical plantations. About 6 hectares of tropical forest are cut per year for every hectare put into forest plantations.[197] About 2.6 million hectares of new plantations are planted yearly in the South, but only about 1.8 million survive.[198] Eucalyptus, pine, teak, and acacia are the main species planted in tropical plantations.

Plantations play an important role in satisfying future demands for wood and fibre. However, when tree monocultures replace native forests, they transform diverse forest ecoystems into high-yielding, genetically uniform tree farms.[199] When industrial tree plantations are based on uniform, introduced species, the native biodiversity is inevitably lost. According to WWF forestry consultant, Nigel Dudley, "Replacing old-growth, natural forests with plantations gives the impression that forests are being restored. But a plantation is about as similar to a natural forest as a football pitch is to a flower-rich meadow."[200]

Traditional Knowledge and Sustainable Forestry

Traditional forest management practices are increasingly recognized as important measures for maintaining and sustainably using biodiversity.[201] Recent studies of moist tropical forests, previously thought to be "pristine" and "unmanaged," reveal that even the most remote "natural" forests are the products of human intervention, selection and management.[202] Traditional practices in community forestry include agroforestry, shifting

Non-wood products and services



Many of which have long been used by people living in and around forests, are increasingly appreciated as a source of sustainable development. Many food crops and industrial, commercial nd pharmaceutical products originated as non-wood forest products. The economic and social incentives provided by non-wood forest products encourage conservation and offer a defense against the loss of biodiversity.

cultivation, sacred groves, forest gardens, collection of non-timber forest products, and highly selective timber felling, among others.

Agroforestry – the integration of trees, crops and livestock – is both an ancient practice and a new field of scientific study. Agroforestry not only supports rural communities and sustains agriculture, it also conserves the genetic resources of valuable tree species and crops. Present-day Mayan farmers in southern Mexico and Central America, for example, manage as many as 60 to 80 tree species in an individual forest garden, and as many as 200 species in a village.[203] In addition to trees selected for food, firewood, building materials and medicine, nitrogen-fixing tree species may be selected to maintain soil fertility, leguminous trees are used to shade coffee and cacao crops, while other trees are planted for fodder, or to regenerate fallow lands.[204] Building on traditional knowledge, new research on agroforestry aims to give small and subsistence farmers new techniques to intensify and diversify agricultural production, and reclaim degraded land.[205]

Community-based and controlled forest management is emerging as one of the most promising strategies for slowing tropical deforestation.[206] Ideally, community-based management systems not only control and regulate the harvest of timber species, but also integrate practices such as non-timber product harvesting, the marketing of lesser-known tree species, restrictions on harvesting to protect soil and water quality and to protect wildlife.[207]

In parts of Southeast Asia, governments are experimenting with joint management programmes by transferring responsibility for publicly-owned, state-managed forests to some degree of local-level management and control. In their recent study of "community based" or "joint management" forest programmes in Asia and the Pacific, researchers Owen Lynch and Kirk Talbott explain that some national governments invite community involvement because once-vast forest resources have dwindled to the point where they can no longer satisfy extractive, commerical industries.[208] In other words, there's little forest left to lose. Forced to acknowledge the failure of state-managed systems, some governments are turning to forest-dependent communities, many of whom have ancestral rights to forests, but have been typically marginalized or disenfranchised by government forest policies in the past.

The growth of community-based initiatives is impressive. In India, for example, 15 state governments have adopted joint forest management resolutions (as of mid-1992) and over 9,000 village organizations reportedly participate in managing 1.5 million hectares of government forest land.[209] A recent national inventory in Thailand found nearly 12,000 community forest management initiatives, including both community institutions created to manage forests, and organizations promoted by schools, temples and other local institutions.[210]

Unfortunately, co-management and community forest initiatives proposed by most governments fail to legally recognize the traditional, community-based property rights of forest dwellers, including indigenous peoples. Lynch and Talbott conclude that many programmes "are little more than short-term, renewable (and cancelable) contract-based reforestation initiatives."[211] Despite major shortcomings, the dramatic growth in community-based forest initiatives could be an important step in building policies that embrace secure community rights and local control.

New approaches to forest management based on sustainable production of non-wood forest products are increasingly popular, especially with some NGOs and consumers in the North. Ideally, the harvesting, processing and trading of non-wood forest products can improve food security and nutrition for the rural poor, while increasing income and job opportunities. The concept of sustainable harvesting of forest products is economically and environmentally appealing, but its success depends on more complex political realities. Ultimately, sustainable utilization of forest ecosystems will succeed only if local and indigenous people have ownership and control of land and forest resources. As forestry researcher Alan Durning puts it, "Secure tenure is the first necessary condition of a sustainable forest economy. Without it, the people who actually manage the world's forests will have little reason, and less authority, to safeguard forest health."[212]

Conservation and Use of Forest Genetic Resources

The future of forest genetic resources depends on putting into practice the closely linked concepts of conservation and use. If properly managed, forest ecosystems can continue to provide goods and services to meet present needs, while at the same time, the genetic resources contained in them can be conserved for future generations.

Forest genetic resources can be conserved on site *(in situ)* and off site *(ex situ)*. *In situ* conservation involves the maintenance of trees and plants in their original habitats or in traditional agroforestry systems. *Ex situ* conservation generally refers to the maintenance of plant parts, tissue or cells in cold storage (i.e. gene banks), or in field collections of growing trees. *Ex situ* collections are an important complement to *in situ* conservation, especially for tree species threatened by loss of habitat. *Ex situ* collections containing a wide range of genetic material are particularly useful to scientists and researchers, but the material contained in gene banks does not continue to evolve as it does in its natural environment.

Sustained utilization of forests, coupled with the maintenance of a network of areas dedicated to the protection of ecosystems and their functions, offers the best approach for lasting genetic conservation. The protection of forests does not require the creation of parks or nature reserves that exclude local people. Experience shows that when local people are excluded from protected areas, degradation is more likely to occur.[213] Conservation policies are more likely to succeed if they work with local people to use and enhance forest biodiversity as part of their livelihood, incorporate local systems of knowledge and management, and support local ownership and control of resources.[214]

International Mechanisms for Sustainable Forestry

Inter-governmental institutions for protecting and conserving the world's forests have been the subject of considerable controversy and uncertainty over the past 15 years. In the midst of a worsening global forest crisis, the intergovernmental community floundered. In 1994, the US-based environmental NGO, World Resources Institute, concluded that, "Existing institutions have been heavily criticized and weakened to a point where there is no clear institutional leadership on forest issues at the global level; at the same time, there is little agreement on the shape or structure of new institutions."[215] With the creation of the Intergovernmental Panel on Forests in April, 1995 there is a new focus for intergovernmental political debate on forests, and renewed hope for reaching consensus on management, conservation and sustainable development of all types of forests. The following is a brief summary of some of the major institutions and arenas for intergovernmental forest policy.

"Wild" Maïze Managed by Farmers

When "wild" stands of *Zea diploperennis* (perennial maize) were first identified by plant explorers in western Mexico in the late 1970's, conservationists pressed for the establishment of nature preserve to conserve them in their natural habitat, the fast-disappearing forests of Sierra de Manantlan. Experts feared that local farmers living nearby, in constant need of grazing land for their cattle, would soon eradicate the few remaining patches of wild maize by grazing cattle in the area. A nature reserve was eventually established, and farmers no longer threatened the rare *diploperennis.* But within a few years, the forest began to invade the fields of wild

Forests: Where's the Political Debate?

United Nations Food and Agriculture Organization (FAO) – Historically, FAO has been the lead intergovernmental body on global forestry issues within the UN system. FAO activities in the conservation of forest genetic resources are guided by the FAO Panel of Experts on Forest Gene Resources, established over 25 years ago. FAO is widely acknowledged for its scientific and technical expertise, particularly relating to forest genetic resources.

FAO's forest policy has provoked blistering criticism from NGOs over the past decade. Most of the criticism centered on the Tropical Forestry Action Plan (TFAP), launched in 1985, and administered by FAO. The TFAP, directed by the World Bank, the FAO, UNDP and the World Resources Institute, was conceived as an international coordinating mechanism to increase investment in countries with tropical forest and promote programmes to check deforestation. But TFAP was sharply criticized by NGOs for ignoring the policy-related and root causes of deforestation, increasing rural impoverishment, and accelerating rather than curbing tropical deforestation – especially in primary forests.[216] In 1990, the World Rainforest Movement was joined by some 50 NGOs from 15 countries who called for a moratorium on funding for the TFAP until it was radically restructured. NGOs and governments have also criticized FAO's record on participation, and have called for improvement in FAO's involvement of women, indigenous peoples, NGOs and the private sector.

In recent years, FAO has completed internal reforms of the TFAP and its forest department. Historically, FAO's Committee on Forests has been the undisputed leader within the UN system on global forestry issues. But this is no longer the case. FAO continues to be recognized for its technical expertise and activities, but the political debate on forests has now shifted to other intergovernmental fora – the primary venue being the Intergovernmental Panel On Forests created by the Commission on Sustainable Development in 1995 (see below).

The 1992 United Nations Conference on Environment and Development (UNCED), Agenda 21, and the Conventions on Biological Diversity and Climate Change all reinforce the critical role of forests in sustainable development and food security. Chapter 11 of Agenda 21, "Combatting Deforestation" outlines voluntary actions for conservation and development of sustainable forests. The UNCED also drew up a non-legally binding authoritative statement of principles for the management, conservation and sustainable development of all types of forests, know as the "forest principles." UNCED's consensus on forest principles, though voluntary, represents the first-ever commitment on responsibilities beyond national boundaries. The principles respect national sovereignty over forests and request all countries to adopt sustainable patterns of production and consumption. The responsibility for implementing agreements rests with national governments.

The United Nations Commission on Sustainable Development (CSD) will review progress on forestry issues in 1997. Recognizing the special need for intergovernmental political debate on forests, the CSD recommended in April 1995 the establishment of an

maize. The plants were crowded out and began to disappear. It was soon discovered that the local farmers had been intentionally conserving the "wild" *diploperennis* by a carefully regulated practice of grazing the dry fodder during the dormant season. This practice controlled the growth of the surrounding forest without harming the *diploperennis.* As plant geneticist Donald Duvick observes, "It seems that the farmers knew exactly what they were doing, and had more wisdom than the well-meaning environmental scientists."

Source: Donald N. Duvick tells this fascinating story in his article entitled, "Biotechnology is Compatible with Sustainable Agriculture," *Journal of Agricultural and Environmental Ethics* 1995, 8(2), 112–125.

"Open-ended ad hoc Intergovernmental Panel on Forests (IPF) to address the worsening forest crisis worldwide and intergovernmental actions needed to address these problems.

The IPF is currently the focal point for resolving intergovernmental forest issues. The IPF is not an implementing body; it meets four times and will submit recommendations to the Fifth Session of the CSD in 1997, when it is scheduled to review forest principles. The IPF's mandate is complex and broad. It includes: implementation of UNCED decisions relating to forests at the national and international level; international cooperation in financial assistance and technology transfer; review and development of technical and socio-economic factors for sustainable forest management; trade and environment policies relating to forest products and services; identifying legal mechanisms and/or institutional roles for achieving these goals. Programme elements with special significance to food security include, among others, attempts to look at underlying causes of deforestation and traditional forest related knowledge.

CIDA PHOTO: ROGER LEMOYNE

The International Tropical Timber Agreement under its coordinating body, the International Tropical Timber Organization, was established in 1983 as an intergovernmental body outside the UN system. The primary focus of the ITTO is the promotion of tropical timber as a commodity; the vast majority of its budget comes from Japan. ITTO has equal representation from tropical timber "producing" nations and "consumer" nations in the industrialized world. Attempts to broaden the timber agreement to include binding commitments to environmentally sustainable forest management in both tropical and temperate areas have been unsuccessful to date. In 1993, the ITTA was re-negotiated, but it has not yet entered into force. The ITTA now operates under a "successor agreement" that was opened for signature 1 April 1994.

The World Commission on Forests and Sustainable Development is often described as a "Brundtland Commission" for forests. It is co-chaired by Ola Ullsten, former Prime Minister of Sweden and Emil Salim, former Minister of Population and Environment of Indonesia. Established in 1995, it is an independent dialogue outside of the UN system that provides a forum for principal stakeholders in global forestry debates with the aim of addressing constraints and promoting implementation of forest decisions in Agenda 21 and the Forest Principles. The Commission plans to hold five regional hearings 1995–1997. A final report on regional and international policy reforms for equitable and sustainable forest management is expected in time for the CSD's 1997 review of forests.

Criteria and Indicators: Regional Processes – Several regional meetings have been held by governments (with some participation from NGOs and international organizations) to develop "criteria and indicators" of sustainable forest management. Regional meetings now underway include the Montreal, Helsinki and Tarapoto processes, among others. While much of the discussion on criteria and indicators focuses on the scientific basis for sustainable forest management, NGOs are pressing for the inclusion of social and economic criteria, particularly the need to acknowledge the rights of indigenous and other forest communities.

The Forest Stewardship Council is an NGO-initiated effort to harmonize forest product certification programmes around the world. With headquarters in Oaxaca, Mexico, FSC's members include NGOs (such as WWF, Greenpeace, and Friends of the Earth) as well as timber traders, indigenous peoples organizations and community forest associations. FSC was founded in 1993 to develop a model for the labeling of "good wood" – a process for assessing the forest sources and methods used in extracting timber so that consumers of timber (and, in some cases, non-timber products) can choose to support socially and ecologically sound forest management.

The Consultative Group on International Agricultural Research (CGIAR) is staking a higher profile in forest-related research and policy, believing that poverty alleviation, through increasing agricultural productivity, is key to addressing tropical deforestation. In 1996, CGIAR invested $24 million (approximately 8% of its total budget) in forest research at two CGIAR research institutes specializing in tropical forestry: the Center for International Forestry Research (CIFOR) based in Indonesia and the International Center for Research in Agroforestry (ICRAF) based in Kenya. The CGIAR uses a mix of science-based approaches, including genetic improvement of "cinderella trees," agro-forestry, research to intensify agricultural productivity on existing crop land, as well as a system-wide programme dubbed "Alternatives to Slash-and-Burn." Many NGOs, including RAFI, view CGIAR's new-found enthusiasm for forests with suspicion, fearing that an emphasis on agricultural intensification and new technologies will promote a second, non-sustainable Green Revolution that will drive still more of the world's small farmers off their lands.

In reviewing the myriad multilateral approaches to the issue of forest conservation, the overwhelming impression is one of political deadlock. Timber-exporting countries, by and large, are neither prepared to recognize the rights of indigenous peoples nor the need to conserve. Timber-importers, heavily influenced by corporate interests, are not interested in conserving forest diversity or in assuring the rights of indigenous peoples. The current situation is disgraceful and untenable.

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152 *Forest Resources Assessment 1990, Global Synthesis*, p. ix.

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179 *Forest Resources Assessment, 1990: Tropical Countries.* FAO's assessment is considered the most authoritative statement on forest status globally, but it is only as good as the national data provided and the statistical model used. The study is based on national forest inventory reports, and estimates calculated using a statistical model. The assessment also used satellite images for 1980 and 1990 at statistically chosen sample locations covering 10% of the tropics. According to FAO, current national capacity for monitoring forest change is limited. No country has carried out a national forest inventory containing information that can be used to generate reliable estimates of the total woody biomass or biodiversity.

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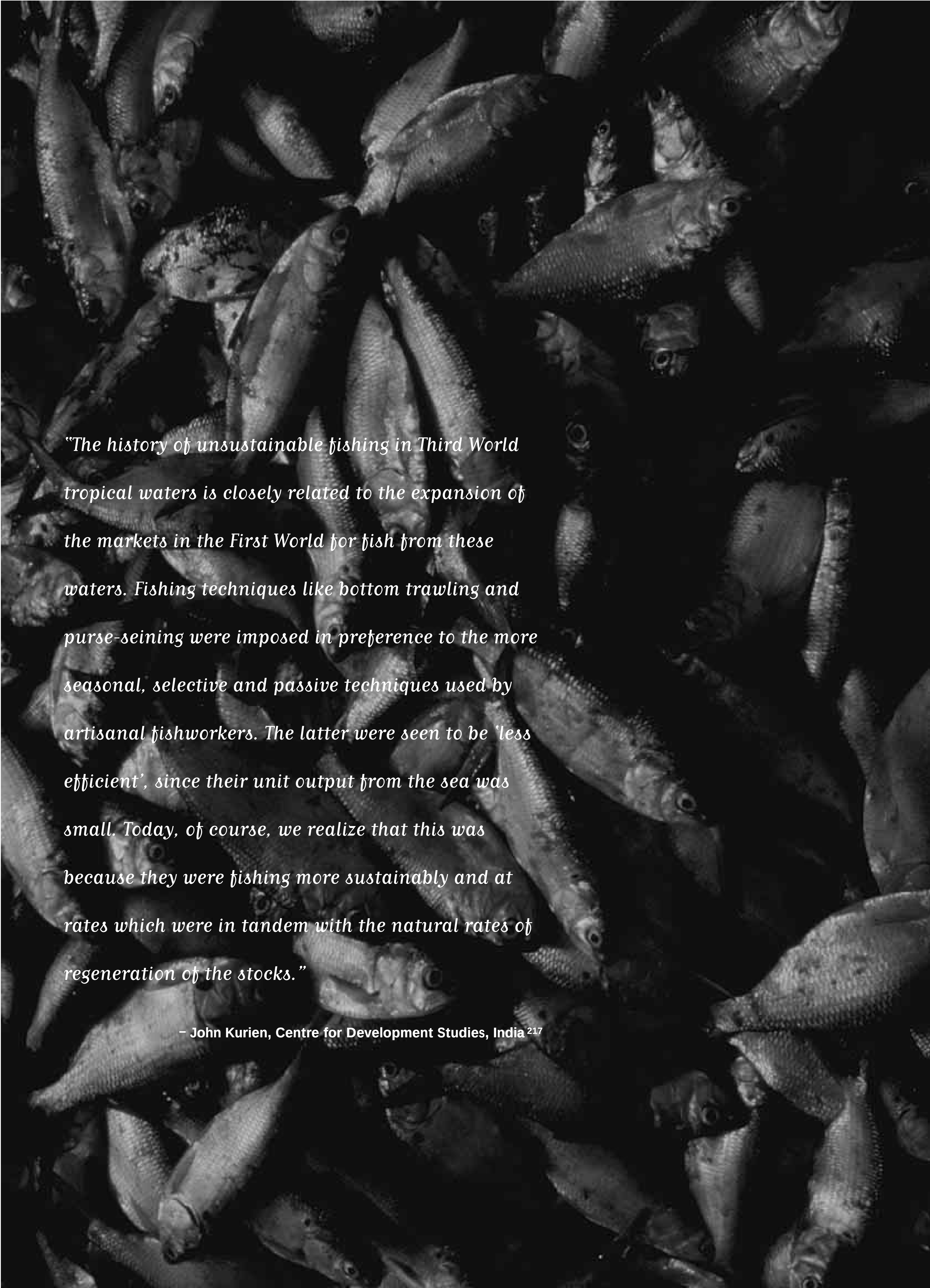


"The history of unsustainable fishing in Third World tropical waters is closely related to the expansion of the markets in the First World for fish from these waters. Fishing techniques like bottom trawling and purse-seining were imposed in preference to the more seasonal, selective and passive techniques used by artisanal fishworkers. The latter were seen to be 'less efficient', since their unit output from the sea was small. Today, of course, we realize that this was because they were fishing more sustainably and at rates which were in tandem with the natural rates of regeneration of the stocks."

– John Kurien, Centre for Development Studies, India[217]

CHAPTER 7

FISH AND AQUATIC LIFE

Introduction

Oceans, coastal waters and estuaries cover 71% of the earth's surface, but we know relatively little about their biotic wealth. Named terrestrial species outnumber those in marine environments by seven to one.[218] But as recently as 1992 scientists speculated that the deep sea could harbour 10 million species that have not been described and named, a diversity of species rivaling that of lowland tropical forests.[219] Nearly half of all animal phyla are exclusively marine. The most recently identified – a new form of life that dwells on the lips of the Norway lobster – was discovered in 1995.[220]

Freshwater ecosystems cover less than 2% of the earth's surface, and account for about 0.009% of Earth's water – a tiny pool of water that is disproportionately rich and vital to sustain life. An estimated 12% of all animal species and 40% of all recognized fish species (8400 species) inhabit freshwater ecosystems.[221] Worldwide, freshwater ecosystems are imperiled. At least one-fifth of all freshwater fish are already extinct or seriously endangered.[222] Because of these losses, and the extent to which freshwater ecosystems are degraded, R.S.V. Pullin of the International Centre for Living Aquatic Resources Management (ICLARM) in the Philippines warns that it is increasingly difficult for fish breeders to locate and collect genetic materials from healthy or relatively undisturbed populations in the wild.[223]

Fish genetic resources must be conserved and utilized because they are the key to maintaining the viability of cultured and natural fish populations. They enable species to adapt to environmental change and they provide the opportunity for genetic improvement programs in aquaculture.

Tropical waters are the richest in terms of species diversity.[224] The Indo-West Pacific Ocean, for example, contains an estimated 1,500 species of fish and over 6,000 mollusc species, compared to only 280 fish and 500 mollusc species in the Eastern Atlantic.[225] Brazil claims more than 3,000 freshwater fish species, three times more than any other country.[226] An estimated 40 percent of freshwater fishes in South America have not yet been classified.[227] Thailand may have as many as 1000 species of freshwater fish, but only 475 have actually been documented.[228]

Aquatic Harvest

Over 75% of the fish consumed by people still comes from the hunting of wild species in natural environments.[229] Aquaculture, which accounts for the remainder of the catch, refers to all types of farming in enclosures such as ponds, tanks, pens, etc., as well as inland culture-based fisheries. Over the past decade, the fastest growing portion of the world fish supply has come from aquaculture.[230] Approximately 85 percent of the global catch is

CIDA PHOTO: PAUL CHIASSON

finfish, with shellfish (molluscs and crustacea) accounting for most of the remainder. Numerous other resources such as aquatic plants (seaweeds) and turtles, though important for local economies, account for a small percentage of harvested organisms.

The contribution of aquaculture to world fish production is increasing dramatically, and has offset losses from capture fisheries over the past decade. Fisheries experts believe that future expansion of aquaculture offers the best hope for maintaining per caput fish consumption levels in the future. In 1993, aquaculture accounted for 16 percent of total world production of fish, and 23 percent of food fish supplies.[231] Aquaculture production of freshwater fishes already exceeds that of production from freshwater capture fisheries. Globally, half of all salmon is no longer caught in the wild, but farmed; the same is true of shrimp culture. By contrast, aquaculture supplies only 5% of the total marine fish production. Aquaculture production is heavily concentrated in the South; Asia accounts for 84% of world aquaculture, and China accounts for about half of the total world production.

CIDA PHOTO: NANCY DURREL McKENNA

Importance of Fisheries

Fishing, fish processing and fish trading have provided the basis for food security, employment, income and cultural traditions in coastal and inland communities for centuries.

Fish contribute substantially to the world food supply, either directly for human consumption, or as feedstuff for livestock (about 28% of the total world catch is used as animal feed).[232] Worldwide, fish provides about 17% of the animal protein in the human diet. Over 200 million people around the world depend on fishing and related industries for their livelihoods.[233]

Intensive Aquaculture: The "Blue Revolution" Turns Brown?

People around the world have practiced small-scale aquaculture for centuries. Today, commercial aquaculture is the fastest growing food production sector in the world.[268] Despite spectacular growth, the prospect for continued expansion is questionable because large-scale export-oriented fish farming has been socially and environmentally destructive to many coastal areas, and its production too costly to provide large amounts of food for poor people. In Malaysia, India, Bangladesh, Ecuador and the Philippines, among others, development of intensive aquaculture has sparked heated protests over land use and resources, because local people's sources of food and income have been threatened or destroyed by commercial, high-input aquaculture.[269] In parts of Asia, thousands of hectares of rice paddies have been

For millions in the South, fish is often the main source of animal protein. According to FAO, fish provides 29% of the total animal protein consumed by Asians, 19% by Africans and 8% by Latin Americans. Fisheries also provide a significant source of employment: Fisheries Specialist, Brian O'Riordian, of the Intermediate Technology Development Group (UK) estimates that 100 million people in the South, mainly poor people, depend upon small-scale fishing for all or part of their livelihood.[234]

Threats to Marine Biological Diversity

The loss and degradation of biodiversity in marine ecosystems has profound implications for food and livelihood security – particularly in the South. In 1990, eminent marine biologists solemnly concluded that "the entire marine realm, from estuaries and coastal waters to the open ocean and the deep sea, is at risk."[235] Tragically, no place in the ocean is so remote that it has not been marred by human activities – pollutants have even been found on the deep-sea floor.[236] Though fish stocks are a naturally-renewable resource they are being depleted at a non-sustainable rate, and aquatic ecoystems are being destroyed.

The marine species and ecosystems suffering most are in coastal waters closest to humankind. Already 66% of the Earth's population lives within 60 km. of coasts, and migration towards these areas is increasing.[237] Inland pollution and other environmentally-degrading activities ultimately affect marine biodiversity because oceans function as a sink for carbon dioxide, eroded soils, contaminants, fertilizers, human and industrial wastes. More than 90% of the global fish catch comes from the 10% of the oceans closest to land. An estimated 44% of all pollution entering the ocean is from runoff and discharges from land (mainly through rivers), 33% from atmospheric pollution, 12% from maritime transportation (oil spills and discharges), 10% from the deliberate dumping of wastes, and 1 percent from offshore mining.[238]

Over-exploitation and over-capacity of fisheries, pollution and habitat destruction, and the introduction of exotic species are the primary activities that imperil fish genetic resources worldwide. Both marine and freshwater ecosystems are imperiled; but the following section focuses primarily on marine genetic resources.

Fished Beyond Limits – Overexploitation and Overcapacity

FAO's 1995 world fisheries report estimates that 70% of the world's marine fish stocks are either fully exploited, overfished, depleted or recovering from overfishing. Since 1989, the global fish catch has stagnated and its quality has declined. Virtually all commercially valuable marine species are overexploited. Of the world's 15 major marine fishing regions, productivity in all but two has fallen. In four of the Atlantic fisheries and one of the Pacific fisheries total output has dropped over 30%. Only the Indian Ocean fisheries are still increasing total output – though these are likely pushing the limit.[239] Declining catches have translated directly into job losses for over 100,000 people in recent years – and now

replaced by high-value shrimp farming, or their productivity reduced by wastes generated by neighboring aquaculture enterprises.[270] Intensive aquaculture has destroyed fragile mangroves that are essential spawning and nursery areas for many marine species. In the Indo-Pacific area more than one million hectares of mangrove forests have been converted to aquaculture ponds.[271] Ecuador has lost 144,000 hectares of mangroves to shrimp ponds. With half of the world's mangrove forests destroyed, the world's coastal fishers may have lost an estimated 4.7 million tons of potential annual fish catch, including 1.5 million tons per year of shrimp.[272]

Intensive shrimp aquaculture in many Asian countries, most notably Taiwan and Thailand, has recently been plagued by severe disease outbreaks caused by self-contamination of shrimp ponds.[273] In 1994, diseases in shrimp caused losses of $4 billion yuan in in one district of China.[274] Massive crop failures due to disease and self-pollution call into question the continued viability of high-input, intensive aquaculture in all parts of the world.

threaten the livelihoods of millions more.[240] With the collapse of the Canadian cod fishery, for example, some 80,000 fishermen and women have gone on welfare.[241]

Fueled by huge capital investments, abundant fossil fuels and modern technology, the global fish catch has increased more than four-fold in the past 40 years. The world's industrial fishing fleet has doubled in size since 1970 – from 585,000 to 1,200,000 vessels – and now has twice the capacity needed to bring in the maximum sustainable catch.[242] Experts predict that if Iceland and the European Union cut their fleets by 40%, and Norway by two-thirds, these countries would still catch as much fish as they do today.[243]

The over-capacity of industrial fleets is a direct result of government subsidies that underwrite the growth of national fleets. But bigger, high-technology fleets have not proved a sound investment. The FAO estimates that in 1989 government subsidies worldwide amounted to a staggering US$54,000 million – resulting in a catch valued at only $70,000 million.[244] An estimated 46% of the value of all fish landed is required as return on capital invested in industrial fleets.[245] Government subsidies in both the North and the South favor commercial fishers over small-scale, traditional ones. These subsidies not only consolidate fish resources in the hands of the rich and powerful, but they also threaten the future livelihoods of 15 to 21 million small-scale and traditional fishers (90% of all fishers), who are the mainstay of coastal communities worldwide.[246]

The threat to marine biodiversity from over-exploitation cannot be measured in extinct species. While no commercially fished marine species is known to have become extinct in modern times, non-sustainable fishing practices have devastasted fish stocks, genetic diversity and marine ecosystems.[247] Experts conclude that "overexploitation not only diminishes species' populations and reduces economic return, but also causes genetic changes in the exploited populations and alters ecological relationships with the species' predators, symbionts, competitors, and prey."[248]

Using costly and sophisticated technologies such as depth-sounding equipment, satellite data and spotter aircraft, high-intensity lamps, 100-metre factory-freezer trawlers, non-selective drift nets, and bottom trawls, industrial fleets are driving some species to the brink of extinction and destroying natural ecosystems in the process. The following are just two examples:

- Industrial fleets in the North Pacific have employed massive driftnets to capture squid and tuna, using up to 3.5 million kilometers of synthetic netting per annum – enough to circle the globe 88 times! Not surprisingly, some 40% of the catch netted in these "wall of death" driftnets is reportedly discarded as bycatch, including up to 200 nontarget species.[249]
- Industrial shrimp trawlers, capable of scraping 1 sq. kilometer of seabed in 10 hrs., profoundly disturb the seabed and its species. Trawling destroys the burrows of bottom dwelling species, mangles huge numbers of nontarget species, and increases suspended

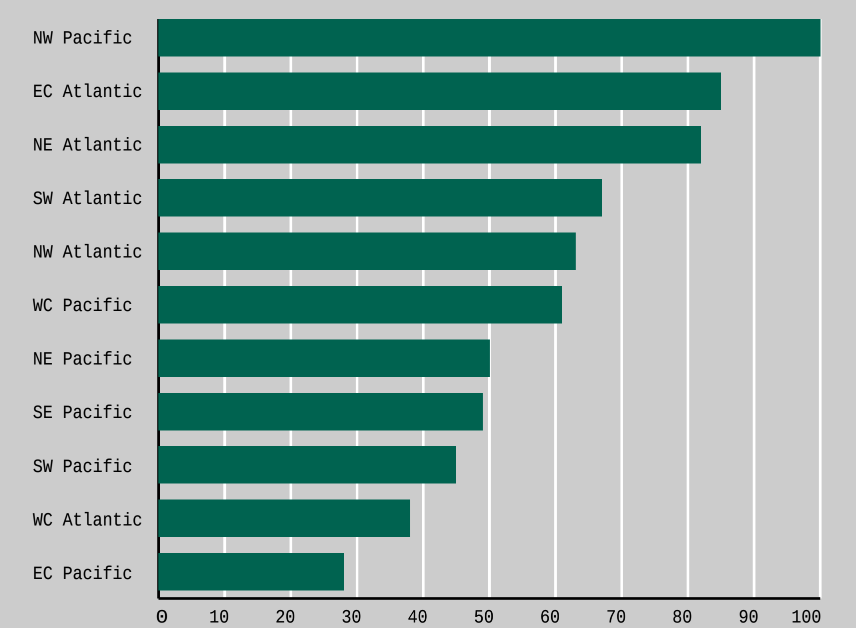
Introduction of Exotic Species

"There is nothing more insidious as an agent of extinction than exotic species."[275]

The introduction of non-native fish species, whether intentional or accidental, has contributed greatly to the loss of fish genetic resources in both marine and freshwater ecosystems.

The introduction of the Nile perch in Africa's Lake Victoria is a classic example. In the late 1950s, British colonists introduced the Nile perch as a sport fish in the world's second largest lake.[276] Because of the large size and voracity of the Nile perch, many of the smaller native species in the lake have become extinct. Some scientists speculate that 200–300 species of fish may have been

Percentage of assessed stocks fully fished, overfished, depleted, or recovering, by area, 1992.



SOURCE: *FAO*

sediments. Shrimp fisheries in the northern Gulf of Mexico (USA) and the Sea of Cortez (Mexico) sweep the entire trawling grounds several times per year.[250]

Inefficient and wasteful practices capture fish that are too small, and leave too few capable of reproducing. As a result, stocks are being depleted to the point where they cannot recover. Shrimp trawl fisheries have one of the highest levels of bycatch and discard rates: 70 to 100% of the catch is thrown back into the sea either dead or dying. The FAO estimates that some 27 million tons of fish, or about 25% of all reported marine landings are discarded annually as bycatch.[251]

International Fish Trade: Net Loss for the Poor?

The impact of over-exploitation of fisheries will be felt disproportionately by poor people in the South. The net flow in world fishery trade is from the poorer to the richer countries. No other animal protein source is exported in such massive quantities from South to North. Approximately 38% of all fish landed enters into international trade. In 1993, developing countries accounted for approximately 66% of the global catch, and 49% of the value of world fish trade; the South's export earnings from fish in 1993 amounted to US$20,109 million, out of the world total of US$41,193 million.[252] The South increased its share of exports between 1970 and 1989 from 32 to 47 percent of the world total.[253] The

lost.[277] The exploding population of Nile perch is now making Lake Victoria one of the most productive lake fisheries in the world, yielding 200,000 to 300,000 metric tons per year.[278] In 1976 perch accounted for only 0.5 of Kenya's commercial catch; that proportion rose to 68% in 1983. But increased productivity may come at enormous ecological and social cost. Lake Victoria supports the livelihoods of an estimated 30 million Africans. Local artisanal fishing communities have lost species which traditionally fed people and supported the local economy. The lake is increasingly providing fish as an export commodity, rather than a local protein source.

The Nile perch is not the only alien species plaguing Lake Victoria. Water hyacinth, native to South America, was first seen in the lake in 1989. With no predators in Africa, a single plant can spread to 100 sq. metres in a few months time, choking off oxygen from the water, clogging intake pipes and providing a breeeding ground for disease-carrying vectors such as snails and mosquitos.[279] The long-term impacts remain to be seen, but these examples illustrate how alien species can wreak havoc in new environments.

North imported 76% of all fish traded as food on the international market from 1988–1990.[254] Japan, the European Union and the USA together account for 75% of the total value of world fish imports in 1993.[255]

Increased participation in commercial markets can generate valuable foreign exchange for developing nations. According to FAO, in 1993 the net surplus of the South's exports over imports of all fish traded as a commodity was more than US$11,000 million – exceeding tropical export earnings from coffee, tea, rubber and cacao combined. But global trade driven by market forces can also lead to intense competition and declining catch rates for traditional and small-scale fishers, and less food for protein-deficient people in the South. The combination of rising fish prices due to increasing world demand, and scarcity due to overfishing is making fish unaffordable to increasing numbers of poor people.

In Search of Sustainable Fisheries

If managed correctly, fish can provide a sustainable source of food and livelihood security. FAO estimates that the marine environment could sustainably yield about 100 million tons of fish per year – but only if fisheries are given time to recuperate. Unfortunately, modern fisheries management has been likened to "controlled plunder" because governments are often ill-equipped or lack the political will to define, monitor and enforce regulations. As the *Economist* magazine put it, "after 18 years of management, overfishing in developed-country waters is worse than ever."[256] Quotas and licenses tend to concentrate access to fishery resources in the hands of powerful interest groups, and often ignore or disadvantage small-scale and traditional fishers.

New approaches are needed if fishing is to continue to provide food for poor people and sustain livelihoods of coastal communities. A "precautionary approach" to fishery management, which aims to protect fish populations before they crash, is now being discussed in international fora. Action must also be taken to restrict if not ban destructive and wasteful fishing technologies, and to address the industry's excess capacity by phasing out government subsidies.

Who Will Fish?

Fishing policy can no longer be made without regard for its social impacts. Greater recognition and support of small-scale fisheries and fishing communities is imperative. Peter Weber of the Worldwatch Institute makes a strong argument for public policies in support of small-scale and traditional fishers.[257] Of the world's 15 to 21 million fishers, over 90% are small-scale fishers, who use traditional equipment or operate small, relatively modern boats. This sector of the world's fishing industry has about the same capacity to bring in

Transgenic Fish: Will they Drown the Gene Pool?

As of mid-1996, no genetically engineered fish variety is available commercially, but several companies are developing transgenic broodstock which they hope to market by the year 2000. About 50 labs around the world are conducting research on transgenic fish; successful gene transfers have been reported for at least 20 species of fish. Experiments to engineer clams, abalone and shrimp are also underway. In the U.S., scientists are now mapping the shrimp genome.[280] Most transgenic research focuses on engineering rapid growth and cold tolerance. Longer-term goals include improving reproductive traits and disease resistance.

- A/F Protein, based in the USA and Canada is developing commercial broodstock of its proprietary "Biogrow" Atlantic salmon, engineered with a fish growth hormone gene that reportedly reach market size, 6–10 lbs., in 12–18 months, instead of the usual 3 years or more. The company has filed US and worldwide patents on the gene and transformation method involved in accelerating growth rates, and hopes to commercialize its transgenic salmon in 4–6 years.[281]

CIDA PHOTO: DAVID BARBOUR

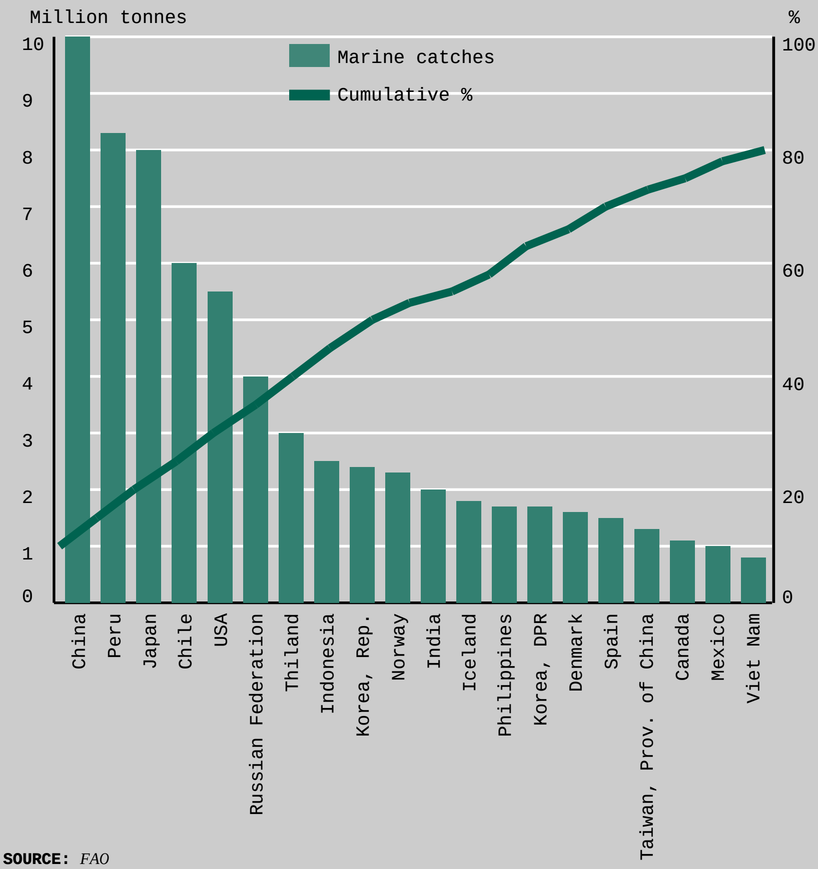
fish as the 1% (200,000 to 300,000) of fishers who work in large-scale industrial operations. Weber points out that small-scale fishers, who are the mainstay of local communities, offer a number of clear advantages: To catch a given amount of fish, smaller-scale fishermen and women tend to employ more people, produce less waste, require less capital and support a diversity of coastal communities. On the other hand, if governments continue to favor large-scale, industrial-style fishing, millions of small-scale fishers and their communities are at risk, and fish catches will increasingly serve only the affluent.

- China's National Laboratory of Freshwater Ecology and Biotechnology is an international leader in transgenic fish technology. Scientists there have successfully bred three generations of transgenic common carp expressing a human growth hormone gene.[282]
- Otter Ferry Salmon of Strathclyde, Scotland is experimenting with salmon engineered for faster growth. A Chilean consortium has reportedly expressed interest in commercial farming of the salmon, that grow 10 times as fast as normal.[283]

Experts are sharply divided over the risks and benefits of transgenic fish.[284] While some view production of bioengineered fish as a potential answer to depleted fish stocks and protein deficient diets, others point out that transgenic fish are certain to escape from enclosed tanks and pens into oceans and freshwater where they pose a severe ecological hazard. If bioengineered fish breed with wild fish, they could destroy or dilute the diversity of the wild fish gene pool – the ultimate source of genes for improving and maintaining the viability of cultured and natural fish stocks. In addition, transgenic fish could ruin aquatic ecosystems by preying on and outcompeting native species.

Potential ecological hazards are compounded by the fact that only a handful of countries have national regulatory policies on transgenic aquatic organisms, and research is regulated by volun*tary* performance standards.

Eighty percent of world marine catches are taken by 20 states



SOURCE: *FAO*

Reservoirs of Hope: Traditional Knowledge and Community-Based Management

It is widely acknowledged that traditional knowledge of fishers and their community-based management systems hold immense value for sustainable fisheries management.[258] Over thousands of years traditional fishing communities in many parts of the world have evolved numerous social systems – often unwritten – to regulate their fisheries and maintain biological diversity. In Indonesia's Molucca islands, for example, the traditional *sasi* principles restrict the harvest of various marine species to ensure their survival;[259] traditional systems of reef tenure and harvest management are practised throughout the Pacific Islands. On Borneo's Kapuas River, traditional communities have developed a system for controlling the harvest of valuable red Asian arawana fish.[260] Customary laws may govern

Pharmaceuticals from the Sea

Today, pharmaceutical corporations routinely undertake genetic prospecting for valuable compounds in remote areas of the tropics – including coastal mangroves, coral reefs and the deep sea. The following examples illustrate not only the commercial value of marine genetic resources, but the vast potential of unknown and unexploited biodiversity.

- In the US alone, over 80 companies are now active in the field of marine biotechnology, and many of these are actively searching tropical waters for biological organisms that may yield promising drugs.[285]
- An Australian pharmaceutical company is collaborating with the Australian Institute of Marine Sciences in a 5-year, US$5 million research programme to screen marine organisms for drug leads.[286]
- In 1989, the US government's National Cancer Institute established two natural products research programmes exclusively devoted to marine products. They have already identified as many as 80 compounds that show some activity

who is permitted to fish in what season and in what areas; some stipulate what sort of fish may be caught; others relate to what kind of fishing gear may be used; and still others govern onshore activities such as processsing, net making, and marketing.[261] Today, traditional management systems are increasingly threatened by modern management practices, population pressures, or environmental changes which disrupt social patterns and usurp local control.

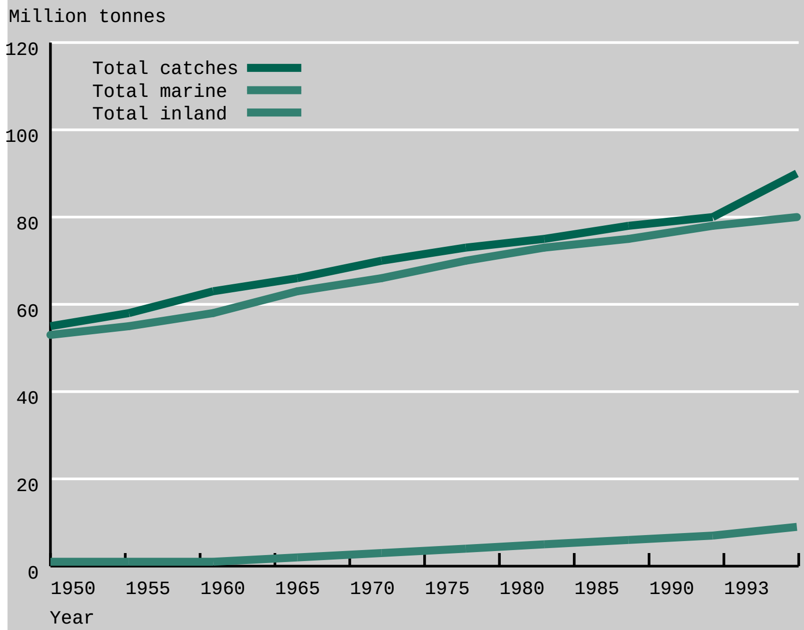
If marine genetic resources are to be conserved, the skills, knowledge and needs of traditional fishers must be built upon. Conversely, traditional management systems can gain from the integration of new technologies and practices. Local, community-based control is an indispensable element for sustainable fisheries, which also requires protection of national governments. Increasingly, the concept and practise of "co-management" is being promoted. Co-management refers to a dynamic partnership where NGOs and organizations representing fishing communities participate with the State in running and regulating the coastal commons.[262] While community-based management remains a central feature, the role of the State in managing and regulating fisheries is also essential. Efforts have also been made to establish management systems which recognize traditional user rights. The governments of Chile, Senegal, and Malaysia, for instance, have recognized the rights of small-scale fishers and have established exclusive "artisanal fishing zones" within coastal areas. In 1989, New Zealand reinforced the traditional fishing rights and legal recognition of the Maori people by passing the Maori Fisheries Act. The Maori people now own 10% of national fish quotas and a 50% stake in New Zealand's biggest fishing company. [263] None of these examples provide perfect solutions, but they demonstrate policy alternatives designed to further the concept of community-based coastal fisheries management.

The International Centre for Living Aquatic Resources Management (ICLARM), based in the Philippines, is tapping traditional knowledge to conserve and utilize fish genetic resources. ICLARM, together with FAO, is assembling a comprehensive database on all of the 24,000 species of cartilaginous and bony fishes in the world. In addition to standard database information, the project will incorporate indigenous knowledge (i.e., common names, traditional management practices, practical or symbolic uses of each species) as a tool to promote research, conservation and utilization of fish species worldwide. FAO and ICLARM deserve credit for their ongoing efforts to include indigenous knowledge in their global database, but they must also take care to protect the rights and knowledge of indigenous communities, and to insure that the information is not commercially exploited without full consent of indigenous peoples.

against cancer, 20 percent of which have never been identified before.[287]

- US-based Magainin Pharmaceuticals recently developed a new class of steroidal antibiotics derived from tissues of the dogfish shark (Squalus acanthias). In 1993 they received a patent on one of these new antibiotics called "squalamine."[288]
- Pharmamar, a Spanish biotechnology company, specializes in developing valuable compounds from marine species. The company takes its samples directly from the nets of its partner, Pescanova, one of Spain's largest fishing fleets. Pharmamar claims 13 marine organisms whose anti-tumour compounds are in trials with the US National Cancer Institute; among them is a microbe from the Caribbean that may prove useful in treating non-Hodgkin's lymphomas. The company has established a marine gene bank with 20,000 accessions. Samples have been sold to pharmaceutical giants Glaxo, Pfizer, Bayer and Sandoz, among others.[289]
- Researchers from Arizona State University recently took extracts from a marine sponge found in the eastern Indian Ocean. The chemical extracts have shown "phenomenally potent activity" against 20 human tumour cells: three leukaemias, six lung cancers, five colon cancers, three melanomas, two ovarian cancers and one renal tumour.[290]

World total fish production by marine and inland waters, 1950–93



A New World Order for Fisheries

Coming to grips with the limits of a finite sea, finding the political will to restructure the global fishing industry and addressing the loss of biodiversity in the global marine and coastal environment, can only be achieved through inter-governmental cooperation and commitment. At the international level, progress has been made in defining problems and setting the course for "a new world order in fisheries." Among the most important institutions and intergovernmental fora are the following:

International Fisheries Law & Upcoming Political Debate

The United Nations Law of the Sea Convention (UNCLOS), opened for signature in 1982 and entered into force in November, 1994 establishes the exclusive rights of coastal nations to manage marine resources within 200 miles of their coastline. The concept of "Exclusive Economic Zones," established by UNCLOS, gives coastal states sovereignty over marine resources within their jurisdiction, but does not impose management practices or conservation guidelines.

The UN Conference on Environment and Development (UNCED) in 1992 and its Agenda 21 (Chapter 17 on Oceans) stressed that further measures are required to implement the UNCLOS. Beyond ownership and fishing rights, States also have a duty to manage and conserve aquatic resources for present and future generations. The concept of sustainable fisheries defined at UNCED provided direction for the elaboration of FAO's Code of Conduct on Responsible Fisheries (see below).

The United Nations Commission on Sustainable Development will conduct a comprehensive review of the Oceans Chapter of Agenda 21 – including living marine resources – in April 1997.

While most people associate *The Convention on Biological Diversity* (CBD) with terrestrial ecosystems, the legally-binding Convention also covers aquatic biodiversity. At the Second Conference of Parties to the CBD meeting in Jakarta (November, 1995), the spotlight focused on marine and coastal ecosystems, with the adoption of the *Jakarta Mandate on Marine and Coastal Biodiversity.* The Jakarta Mandate is significant because it is the first time the international community has addressed – in a comprehensive way – the global crisis of marine and coastal biodiversity loss.[264] The Mandate gives governments who are parties to the Convention a checklist of concrete measures that should be taken to fulfill their obligations under the CBD in marine and coastal environments. It also gives policy guidance to international bodies, and sets in motion a three-year process under the CBD to address the most urgent threats to marine and coastal biodiversity.

International Code of Conduct on Responsible Fisheries: Since 1992, FAO has played a key role in drafting a Code of Conduct for Responsible Fishing. The concept of "responsible fishing" embraces sustainable utilization of fisheries resources in harmony with the environment, and the use of capture and aquaculture practices which are not harmful to ecosystems, resources or food quality. The Code of Conduct, ratified by member states at the FAO Conference in October 1995, is voluntary, and focuses mainly on the responsibilities of states with regard to the sustainability of fish resources, technical management measures, conservation and environmental concerns. Many NGOs participating in the process on the Code's development believe that critical issues such as the rights of fishing communities to livelihood and food security, and the importance of traditional knowledge and management systems, are overshadowed by the Code's emphasis on more technical and biological objectives.[265] Still, the Code is the most comprehensive document that exists on fishing related activities, including management and trade.

UN Conference on Straddling and Migratory Fish Stocks expands on the Law of the Sea and complements the Code of Conduct by addressing conservation and management practices in high seas fisheries – those areas outside the 200-mile exclusive economic zone under the jurisdiction of coastal States. A final Agreement was opened for signature on 4 December 1995, and will enter into force when ratified by 30 member states. The legally-binding agreement: 1) Spells out principles for a precautionary approach to managing fish stocks both within and beyond the areas under national jurisdiction; 2) Advocates the setting up of subregional and regional fisheries management organizations as a mechanism to ensure that conservation and management measures are adopted and complied with; and, 3) Provides for peaceful settlement of disputes between nations.

UN Drift Net Ban: The so-called "Drift Net Ban" adopted by the UN General Assembly in December, 1989 called for an immediate halt to the expansion of large-scale pelagic drift-nets in all regions of the high seas, and for a moratorium on large-scale drift-net fishing in all ocean regions by 30 June 1992. Though an important step, the UN action amounts to a moratorium on increasing driftnet size under certain conditions. It is not a ban. No UN body (including the FAO) has called for a worldwide blanket ban on "wall of death" driftnets, although some nations now limit the length of drift-nets.[266]

ICLARM – The International Centre for Living Aquatic Resources Management, based in the Philippines, is the CGIAR research centre devoted to aquatic genetic resources and sustainable fisheries management. ICLARM has conducted extensive research on genetic improvement of tilapia, a fish species of special importance to small-scale aquaculture in the South. ICLARM recently formed an International Network on Genetics in Aquaculture (INGA) with a focus on genetic improvement of fish species that are farmed in the South.

FAO – FAO is widely acknowledged for its expertise in world fisheries, for which it has gained considerable credibility and stature. Some NGOs have praised FAO for the way it has involved NGOs in the elaboration of the Code of Conduct on Responsible Fishing, describing the process as "a watershed in relations between NGOs and FAO."[267]

At the FAO World Food Summit in November, 1996 NGO's and peoples' organizations put special emphasis on the need for policies to promote and protect the rights of small-scale and artisanal fishing communities as a strategy for addressing food and livelihood security for the poor.

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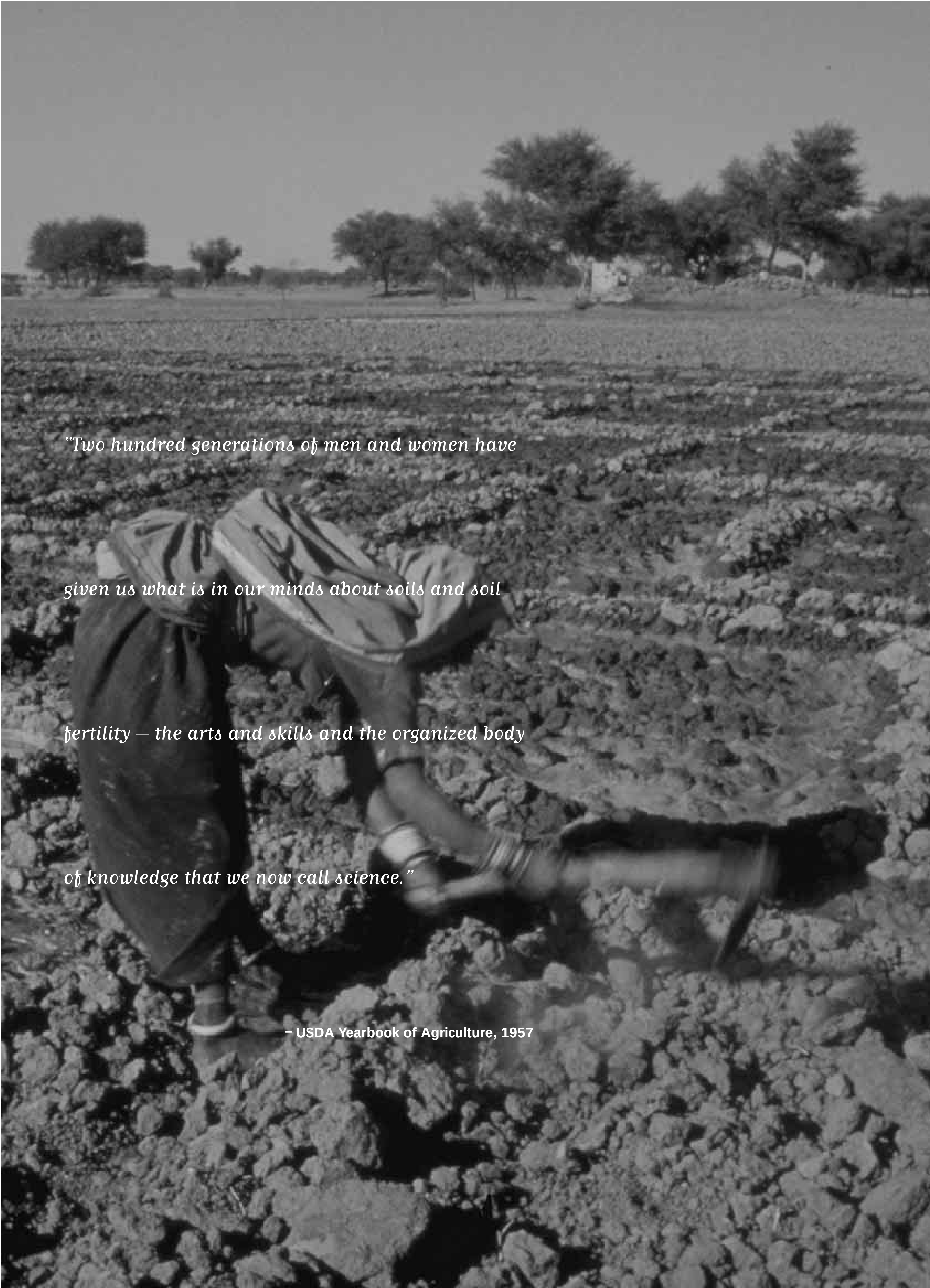

"Two hundred generations of men and women have given us what is in our minds about soils and soil fertility – the arts and skills and the organized body of knowledge that we now call science."

– USDA Yearbook of Agriculture, 1957

CHAPTER 8

SOIL AND MICROBIAL BIODIVERSITY

Though seldom acknowledged in discussions of agricultural genetic resources, soils are "the critical life-support surface on which all terrestrial biodiversity depends."[291] Soils are providers, storers and generators of biodiversity – but they are also one of the most undervalued and poorly researched habitats on earth.[292] At the very time soil ecologists are beginning to uncover the magnitude and importance of life in the soil, the resource itself is literally disappearing off the face of the earth. Human activities are the greatest threat to soil biodiversity:

- Human-induced soil degradation by wind, water and pollution affects about 24% of the inhabited land area of the globe.[293]
- A recent study by the UK's Royal Commission on Environmental Pollution concluded that some 10% of the world's soil has already been lost this century through deforestation, erosion, urban development and other abuses of the land.[294]
- Approximately 30% of the world's arable crop land has been abandoned because of severe soil erosion in the last 40 years.[295]
- Worldwide, soil is being lost at a rate 13 to 80 times faster than it is being formed. It takes about 500 years to form 25 mm of soil under agricultural conditions, and about 1,000 years to form the same amount in forest habitats.[296]

The staggering diversity of soil biota may be orders of magnitude higher than above ground diversity of plants and animals, but no one has yet made an exhaustive census of even one natural habitat.[297] According to the Global Biodiversity Assessment, "a single gram of temperate forest soil could contain 10,000 million individual cells comprising 4,000–5,000 bacterial types, of which less than 10% have been isolated and are known to science;" more than 500 species of soil invertebrates (e.g. snails, earthworms, termites, mites, nematodes, etc.) have been recorded from a beech forest; over 2,500 species of fungi have been identified from a few hectares of land in southwest England.[298] Even moss tussock communities in the Antarctic Peninsula are home to over a hundred species of soil microorganisms and invertebrates.[299] Tropical soil biota, though perhaps richer than in temperate regions, is still relatively unknown and undocumented.

Microbial diversity encompasses a spectrum of microscopic organisms including bacteria, fungi, algae and protozoa. An estimated 50 percent of all living protoplasm on Earth is microbial.[300] There may be 1.5 million species of fungi yet only 5% are described; as many as one million species of bacteria may exist, but only about 5,000 have been described in the last century.[301] According to new estimates by the Center for Microbial Ecology at Michigan State University (USA) a gram of typical soil contains about 1 billion bacteria, but only 1 percent can be successfully grown (cultured) in the laboratory. Fewer than 5% of all microbial species have been discovered and named – and even less is known

CIDA PHOTO: ROGER LEMOYNE

about the diversity within those species.[302] So little is known about most of the microbial world that no one has ever documented the extinction of a bacterium.[303]

Life in the Soil and Life on Earth

Soil biodiversity influences a huge range of ecosystem processes that contribute to the sustainability of life on earth. For example, soil organisms maintain critical processes such as carbon storage, nutrient cycling and plant species diversity. Soil biodiversity plays a role in soil fertility, soil erosion, nutrient uptake by plants, formation of soil organic matter, nitrogen fixation, the biodegradation of dead plant and animal material, reducing hazardous waste, the production of organic acids that weather rocks, and control of plant and insect populations through natural biocontrol.

Through production of food, fibre and renewable forms of energy, soil-based plant productivity supports the livelihood of every person on earth. Soil biota enhance crop productivity because they recycle the basic nutrients required for all ecosystems, including nitrogen, phosphorous, potassium and calcium. Soil organisms enhance the productivity of the soil by increasing water infiltration, thereby reducing surface water runoff and decreasing soil erosion.

CIDA PHOTO: CINDY ANDREW

Termites, earthworms and other burrow-building soil organisms enhance soil productivity by churning and mixing the upper soil, which redistributes nutrients, aerates the soil and increases surface water infiltration.[304] Earthworms and other invertebrates can bring to the surface from 10 to 500 tonnes/per hectare/per year of soil, and thus play a critical role in the formation of topsoil. Cornell University entomologist David Pimentel estimates that the value of soil biota to soil formation on agricultural land worldwide is US$50,000 million per annum.[305]

Indigenous Knowledge of Soils and Microbial Diversity

The properties of certain soils have been recognized and valued by traditional farmers and indigenous peoples for millennia.[318] While they may not be able to identify the exact bacteria or fungi responsible, the anti-tumor, antibiotic or steroid characteristics of certain soils are frequently known and valued by traditional healers. Farming communities have long demonstrated intimate knowledge of soil taxa as well as techniques for altering soil structure and building soil fertility. The following are just a few examples:

Nitrogen from natural and commercial sources is vital to plants and animals. It is the main nutrient required for growth in plants and for building proteins in animals. Biologically fixed nitrogen (primarily nitrogen-fixing microorganisms that live symbiotically on the roots of leguminous plants and trees) makes an enormous contribution to global agricultural productivity. In poor soils, where alternative sources of fertilizer are either unavailable or unaffordable, biological nitrogen-fixation is vital to crop production. Worldwide, an estimated 140 to 170 million tonnes of nitrogen, valued at approximately US$90,000 million are fixed by microorganisms in agricultural and natural systems each year.[306]

Soil biota play a major role in stabilizing and regulating the earth's climate. Global warming is the result of increasing levels of carbon dioxide and other greenhouse gases in the Earth's atmosphere – primarily caused by the burning of fossil fuels by humans. The rate of exchange of carbon between the earth's surface, the oceans and the atmosphere, known as "the carbon cycle", is the primary mediating force with regard to climate change. Through the process of photosynthesis, green plants absorb carbon dioxide from the atmosphere. It is well known that trees and forests store the absorbed carbon in woody biomass. But it is actually soil organic matter that is the major global storage reservoir for carbon. The living microbes, fungi and invertebrates found in the soil are responsible for decomposing carbon and nitrogen and making them available for plant growth, while at the same time contributing to the rate of production and consumption of carbon dioxide, methane and nitrogen.

Despite the importance of soil biodiversity to life-sustaining ecosystem processes, soils are one of the most neglected habitats on earth.[307] In most cases, soil biologists simply don't know which organisms or groups of organisms play the most important roles in ecological processes, they don't know which soil taxa are being lost, or what impact these losses will have in the future.

There is general consensus that we are losing soil biodiversity. Many microbes live symbiotically with higher organisms. Every plant and animal that becomes extinct is likely to take several species of microorganism with it. According to soil ecologist Diana Freckman of Colorado State University, knowledge of soil species remains a "black box" in our understanding of how soil systems function.[308] A study published by the US National Research Council in 1993 noted that "Our lack of knowledge of microorganisms and invertebrates, which are estimated to make up as much as 88% of all species, seriously hampers our ability to understand and manage ecosystems."[309]

Soil ecologists believe that it is essential and urgent to establish the cause and effect relationships between the loss of soil biodiversity and the impact on terrestrial and global ecosystem processes. Only by knowing and understanding life in the soil can we begin to conserve and better utilize its life-sustaining services.

Industrial agriculture has contributed to the neglect of soil biodiversity because conventional soil science has generally relied on the use of purchased farm inputs to overcome constraints and modify the soil environment. (For example, if the soil is dry, irrigate; if soil fertility is low, buy synthetic fertilizer; if pests and weeds invade, spray chemicals). With

Australian bull ants *(Myrmecia gulosa)* have two large glands that secrete a broad spectrum antimicrobial substance. Australian Aborigines traditionally used cloths soaked in this secretion to prevent or treat wound infections.[319]

- To alter their sandy, nutrient-deficient soils peasant farmers in Zimbabwe use termitaria (termite mounds) as a source of clay and plant nutrients – resulting in improved soil structure and higher soil fertility.[320]
- In 1990, the University of Florida (US) patented a Brazilian fungus known to be lethal to fire ants that cause over a billion dollars in damage to US crops. The patent fails to mention the fact that the fungus first attracted the attention of researchers because Brazilian farmers knew that "something" in the soil kills ants.[321]

growing awareness and need for low-input and sustainable agriculture, knowledge of soil biodiversity is increasingly important to future farming systems.[310] A better understanding of soil biota will enable farmers to depend less on modification of the natural environment and place greater emphasis on using biological processes to optimize nutrient cycling, minimize the use of purchased inputs, and maximize the efficiency of their use.

CIDA PHOTO: BRUCE PATON

The Value of Microbial Genetic Resources

Microorganisms (or microbes) are tiny living things that are not visible except with a microscope. They include algae, bacteria, fungi (including yeasts), certain protists (one celled animals that are not bacteria) and viruses. Microbial biodiversity is a vast frontier and a potential goldmine for the biotechnology industry because it offers countless new genes and biochemical pathways to probe for enzymes, antibiotics and other useful molecules.[311]

Worldwide, the economic value of microorganisms is estimated to be "at least many tens of billions of US dollars."[312] Pharmaceuticals of microbial origin account for sales of approximately $35–50 billion per annum in the North.[313] It is the invisible world of microbes that has given us more than 3,222 antibiotics, for example, many derived from soil samples. In 1993, five of the pharmaceutical industry's top-selling drugs were derived from microbes; accounting for more than $4,500 million in annual sales.[314]

The commercial value of microbials extends beyond pharmaceuticals. The total world market for industrial enzymes, all produced by microorganisms, is $1,300 million. Enzymes are natural catalysts that can speed up a chemical reaction. Because the process is biological, they are biodegradable and can be used instead of synthetic chemicals. For example, industrial enzymes are used to enhance detergents, as biological pesticides, to clean up toxic wastes, to replace chemicals in paper and pulp processing, and for oil extraction.

With the use of modern biotechnnology, the potential applications of microorganisms is vast. Scientists are experimenting with genetically engineered bacteria that are capable of producing products such as biodegradable plastics, artificial skin, and fibres that are as strong as spider silk. Maize, rice, potato and cotton are among the crops that have been genetically engineered to produce insecticidal genes from a common soil bacterium, *Bacillus thuringiensis* (Bt). The Bt genes enable the crops to produce a toxic protein that kill insects which feed on the plant. Microbial diversity can play an important role in the decomposition of hazardous wastes. Molecular biologists are attempting to harness specific organisms, or groups of organisms, to clean-up toxic wastes in the environment, or reduce hazardous waste production in industrial processes.

Today, transnational microbe hunters are especially interested in exotic and hostile environments – including boiling hot springs, undersea hydrothermal vents, alkali lakes and the frozen tundra of Antarctica – as a source of unexplored microbial diversity. Bioprospecting for microbes goes, quite literally, to the ends of the earth. The following are just a few examples:

A subsidiary of German agrochemical giant AgrEvo is conducting intensive soil sampling in India. According to German researcher Michael Flitner, the company has already screened over 90,000 Indian soil samples and is building a new, high-effficiency system in Frankfurt for screening plants and soil collected in India.[315]

- When employees of Denmark's Novo Nordisk corporation go on holiday, they take soil-collection kits to gather exotic, enzyme-producing microbes. The father of one Novo Nordisk scientist collected a soil sample from an Indonesian temple which yielded an enzyme that is now widely used by soft-drink suppliers to change starch into sugar.

In 1949, Filipino scientist Abelardo Aguilar sent his employer, Eli Lilly Co., samples of an antibiotic isolated from a soil sample that he collected in his home province of Iloilo. Three years later, Eli Lilly sent a congratulatory letter to Aguilar, promising to name the new antibiotic "Ilosone" after the Filipino province where the soil sample was found. The drug, erythromycin, sold under the brand name "Ilosone" has since earned Eli Lilly millions of dollars, but neither Aguilar nor the Philippines received any royalties, despite Aguilar's 40-year battle to be recognized and rewarded.[316]

- Sponges growing on a coral reef off the coast of Papua New Guinea are the source of a powerful antifungal agent "Papuamine." Because the sponges yield only minute quantities of the antifungal agent, Myco Pharmaceuticals (USA) is now attempting to synthesize papuamine in the laboratory.
- Bacteria found in the whale gut from the last legal Eskimo whale hunt are capable of breaking down toxic petrochemicals. Scientist A. Morrie Craig of Oregon State University has applied for patents on some of the whale gut bacteria, and Pioneer Hi-bred has already secured rights over commercial products that may someday result from the bacteria.
- Bacteriologist Thomas D. Brock discovered a bacterium, *Thermus aquaticus* in the boiling hot springs of Yellowstone National Park (USA) in 1966. An enzyme isolated from *Thermus aquaticus* is the catalyst for the polymerase chain reaction, or PCR, a technique that is widely and routinely used for producing copies of any DNA sequence. Although Thomas Brock donated the bacterium he discovered to the scientific world, it was later patented and now brings royalties valued at hundreds of millions of dollars annually to Swiss pharmaceutical corporation Hoffman-LaRoche.

Microbial Genetic Resources in the International Policy Arena

Despite its growing economic importance, microbial genetic diversity has been under-valued and under-recognized in biodiversity debates. There is an obvious policy gap in the international arena, and it is poor farmers who will likely pay the greatest price for this oversight. The vast majority of microbial culture collections are located in the North, and there is a growing trend toward privatization and patenting of this material. Microbial genetic resources can no longer be disregarded as ubiquitous life forms outside of the mainstream of biodiversity policy debates. Today, the genetic resources of microorganisms are very much an issue in the international policy arena.

Microbial Biodiversity – Where's the Political Debate?

The Convention on Biological Diversity excludes from its scope all *ex situ* germplasm collected prior to the Convention coming into force at the end of 1993. This means that all microbial culture collections, the vast majority of which are located in the industrialized world, are the legal property of the depositor and not of the donor country, regardless of where the germplasm was collected. The U.S.-based American Type Culture Collection, the world's largest microbial culture collection, contains thousands of biological specimens

CIDA PHOTO: PAUL CHIASSON

from the South, dozens of which are the subject of patent claims by Northern pharmaceuticals such as Bristol-Myers, Pfizer and Eli Lilly.

Patent culture depositories are regulated internationally by the Budapest Treaty on International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure administered by the World Intellectual Property Organization in Geneva. Currently, 32 countries are signatories to the Budapest Treaty. An estimated 86% of global microbial collections is held in industrialized nations.[317]

A network of microbial resource centres for the developing world (MIRCENs) was established in the early 1970s by UNEP and UNESCO. Today, there are no policies in place to protect these microbial genetic resources from privatization or to insure equitable exchange of microbial genetic resources in culture collections worldwide. Normally, MIRCENs have a policy of free exchange of microbial materials within the network, but each MIRCEN may decide on a case-by-case basis.

The Uruguay Round of the General Agreement on Tariff and Trade (GATT) incorporates an element called Trade Related Aspects of Intellectual Property Rights (TRIPs) which specifies that microorganisms may not be excluded from patent protection (Section 5, Article 27.2). All countries that are signatories to the World Trade Agreement are now obligated to adopt and implement patent laws for microorganisms and for biotechnology processes applied to living organisms. What is the definition of a microorganism? When is a microorganism patentable? For the purposes of patent protection, there is considerable uncertainty and controversy regarding the answer to these questions. In many countries, the term microorganism extends to cell lines and plasmids – including human genetic material.

The patenting of human genetic material is no longer a theoretical concern, but a shocking reality. On March 14, 1995 the US Patent and Trademark Office granted a patent to the US National Institutes of Health (NIH) for an unmodified human cell line drawn from a 20-year old Hagahai man from Papua New Guinea. It is the first time that an indigenous person's cells have ever been patented. Not only plants, animals and microorganisms from gene-rich ecosystems of the South, but also the genes and cells of indigenous peoples have become targets of Northern scientists and industrial bioprospectors.

Private ownership of human biological materials raises many profound moral, ethical, and political issues. There is no international protocol to protect human subjects from patent claims and unjust commercial exploitation. And there is no mechanism to compensate individuals or communities from whom DNA samples are taken.

Signatories to the World Trade Agreement must determine whether or not human genetic materials are included in its definition of microbial materials. At the Jakarta meeting of the Conference of Parties to the Convention on Biological Diversity held in November, 1995, delegates made it clear that they did not wish to regard human genetic materials as part of the Convention, despite the fact that the legally-binding Convention does not explicitly exclude human biodiversity from its mandate. The World Health Organization has yet to establish internationally-accepted medical ethics protocols covering the commericialization or patenting of human genetic material. There is a serious policy vacuum that some international body must fill.

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PART III: Outstanding Policy Issues

"Law is born from despair of human nature."

– Jose Ortega y Gasset

CHAPTER 9

AGRIGENDA 21

THE EMERGING POLICY AGENDA FOR AGRICULTURAL BIODIVERSITY

We sometimes fail to appreciate how far we have come. On the downward slope of the 1990s, the world's understanding of agricultural biodiversity has improved tremendously from where it was even twenty years ago. This understanding is not only shared by civil society organizations and farmers, but permeates multilateral institutions, many governments and the Convention on Biological Diversity (CBD) – which itself has done much to widen everyone's thinking.

If we are beginning to get the conceptual framework right, however, we are a long way from addressing all the thorny policy and programme issues. We know what the problems are, but we have not solved them all. The following is a brief shopping list of outstanding concerns in urgent need of resolution. The list includes some recommendations for how we might all move forward. Collectively, the seven areas discussed here could be seen as an agricultural biodiversity agenda; sort of an "Agrigenda 21," for the years immediately ahead.

The first two areas relate to the kind of institutional follow-through needed to capitalize on the momentum coming out of the CBD, Leipzig and the Food Summit.

1. Structural Reforms: The most pressing outstanding policy concern facing agricultural biodiversity is the transformation of FAO's International Undertaking on Plant Genetic Resources into a legally-binding Protocol. The goodwill engendered by the Leipzig Process is stirring positive momentum toward this end. When the CBD's Conference of Parties met in Buenos Aires in 1996, that body affirmed its willingness to consider a decision by the FAO Conference that the International Undertaking should take the form of a protocol to the Convention, once revised in harmony with it.

Adjusting the Undertaking is not – despite the goodwill – going to be easy. Although there is probably broad agreement on some important points, the work cannot be completed without a common position on both intellectual property and on Farmers' Rights. The negotiating process is already well underway, but neither farmers nor governments should look for a completed protocol, negotiated and adopted, before 1999.

In the meantime, there are other elements of "structural adjustment" that are necessary and need not wait. Most importantly, work on biodiversity for food and agriculture must be better integrated both in the range of species it addresses and in the connections made between conservation and utilization. The Commission must take responsibility not only for FAO's work with plants (crops and forests) and livestock but also for aquatic species, soil and other agriculturally-important micro-organisms. Farming and fishing communities deal holistically with all species. Especially in a policy-setting forum such as the Commission, the same holistic perspective is essential.

2. Sustainable Action: One of the most important contributions in the adopted Plan of Action is the firm connection made between conservation and development. Farming

CIDA PHOTO: PATRICIO BAEZA

communities are acknowledged, in the Plan, to be active breeders as well as conservers. Again, there is no disconnect between conservation and utilization at the community level and neither should there be as governments widen their engagement at FAO. There should be active work in the Leipzig follow through to ensure that the connection is further strengthened. The connection between conservation and development must also be made more firmly within FAO.

FAO has found itself, not always comfortably, taking a lead role in the UN System addressing the tough questions related to pesticides and integrated pest management (IPM). Indeed, some of FAO's work – notably in Asia – in this field is brilliantly innovative and could serve as a model beyond FAO to the work of other agencies. There is a logical connection between FAO's Leipzig follow-through and the Organization's IPM initiatives that should be encouraged.

Sustainable Agriculture and Rural Development (SARD) has become a theme in FAO and figured significantly in the World Food Summit. A series of international conferences in The Netherlands and Norway have helped to develop this theme. It may be time for FAO, in cooperation with other partners including civil society, to follow-up by convening


CIDA PHOTO: ROGER LEMOYNE

a consultation that could bring together the experience from the work on biodiversity for food and agriculture with its IPM work and other SARD activities.

The third and fourth areas are, by any measure, among the most difficult outstanding issues imaginable. Farmers' Rights and intellectual property have challenged the Biodiversity Convention and the FAO Commission throughout their histories.

3. Farmers' Rights: First introduced into intergovernmental debate at the first meeting of the FAO Commission on Plant Genetic Resources in 1985, Farmers' Rights is now embodied in the International Undertaking on Plant Genetic Resources and the Leipzig Plan of Action, and also in Agenda 21 and the Convention on Biological Diversity. However, little has been achieved in practical terms, and Farmers' Rights still need to be realized. Once perceived as a relatively straightforward counterpoint to Plant Breeders' Rights, the principle of Farmers' Rights grew in the course of the Keystone International Dialogue on Plant Genetic Resources (1988–91) to include the inalienable right of farmers to germplasm, information, financial resources, technologies, and research and marketing systems. The atrociously-dubbed "GIFTS." As FAO and the CBD grappled with the realization of this

widened definition, however, farmers' organizations and indigenous peoples' organizations began to make it clear – most especially at the Leipzig Conference of 1996, that Farmers' Rights, to be effective even in the limited sphere of genetic resources, embodied rights to land, cultural rights, and concepts more closely associated with Human Rights than seeds. Indigenous peoples saw Farmers' Rights in the context of their own struggle for self-determination and claimed Farmers' Rights as a significant sub-set of their larger Rights. In the process of UN conferences and debates, the connection between the practical realization of Farmers' Rights and the questions of access, control, and benefit-sharing related to agricultural biodiversity have led to much heat and little light. The good news is that organizations of small farmers such as Via Campesina and of indigenous peoples such as the Indigenous Peoples Biodiversity Network, have taken the leadership in defining the issues and are cooperating constructively to develop a real and enforceable set of rights under the umbrella of Farmers' Rights.

RAFI and many NGOs are concerned that governments at the CBD and the FAO Commission are anxious to complete their definitions of Farmers' Rights as quickly as possible and to move the issue to the sidelines. In RAFI's opinion, a rushed resolution will only benefit advocates of intellectual property rights – not farmers. Since Farmers' Rights was born in the FAO Commission, that body could determine to convene an extra-ordinary session on the full realization of Farmers' Rights. The goal would be to adopt a binding commitment to the implementation of Farmers' Rights by 1999.

4. Intellectual Property: There is no policy issue more political (and commercial) than that of intellectual property over living resources. The critical questions of access to genetic resources and benefit-sharing cannot be resolved until the world community comes to grips with the dilemma posed by patents on life. To its credit, FAO was the first to recognize this issue back in the 1970s. CGIAR also realized the implications in the 1980s. Now the Biodiversity Convention is faced with balancing the pressures from the North to embrace intellectual property protection as a great way to share benefits – against pressure from some in the South and indigenous and rural communities to reject a ruthless system of monopoly that threatens biodiversity and food security.

In a hastily convened round table in September, 1996, the Biodiversity Convention Secretariat sought the views of civil society, industry and governments on how to proceed with the intellectual property hot potato. At the end of an extended lunchtime exchange, the feuding factions had to admit that not a single word had been uttered that presented intellectual property in positive terms. Every intervention – including those from industry – assumed that patents and Plant Breeders' Rights either destroyed diversity or were at least a complicating factor in conserving diversity. Gone were the old assertions that by stimulating innovation, intellectual property would create diversification and even stir a commercial interest in conservation.

The solution, of course, is to rid ourselves of the problem by abolishing intellectual property over living material. Since this wish will not be realized soon, it may only be practicable to establish monitoring and review mechanisms that will help governments and intergovernmental bodies evaluate the impact of intellectual property on agricultural (and other) biodiversity. The World Trade Organization's Council on TRIPs (Trade-Related Aspects of Intellectual Property) has an obvious – but not exclusive – role to play. Certainly, it should be obligatory for the WTO, in consultation with FAO, to report fully on the impact of intellectual property on agricultural biodiversity when it reviews its progress in 1999. Simultaneously FAO should review the impact of patents and Plant Breeders' Rights. While FAO should confine its study to biodiversity for food and agriculture, the Biodiversity Convention has no such limitation. The CBD should time its own study to coincide with those of the WTO and FAO. Countries of the South who have joined the WTO need not adopt national intellectual property legislation until 2000 or even 2004 (depending on their "LDC" status). They would be politically unwise to adopt legislation before the 1999 reviews.

When the UN General Assembly comes to review progress on Agenda 21 in mid-1997, it will have in hand the important discussions of the CBD and of FAO (including the Leipzig Declaration and Plan of Action). It is abundantly clear that "the fair and equitable sharing of benefits" (language prevalent throughout the chapters of Agenda 21) is not at hand. If the strength of intellectual property monopolies is growing, the rights of indigenous and other rural communities remain largely rhetorical. There are two points here: First, neither Agenda 21 nor anyone else has been able to meet their international commitment to protect and strengthen the rights of the community innovation system. Second,

CIDA PHOTO: CINDY ANDREW

the encroachment of intellectual property regimes into every facet of biological materials, in the absence of mechanisms that protect rural innovators, renders these regimes predators of indigenous knowledge. If the General Assembly suspects this to be so, it should turn the matter over to the International Court of Justice and ask the Court to determine if the application of the Uruguay Round Agreement is unavoidably predatory with respect to indigenous and other rural knowledge – and peoples. An Advisory Opinion from the World Court would normally come within 12–18 months – in time for the various reviews of 1999. The World Court would also have the option of receiving both written and oral testimony. By moving the debate to the level of the Court, governments would override the political gridlock surrounding this issue.

In the meantime, civil society and the entire international community should join with The Crucible Group in its 1994 recommendation that the UN convene an international conference on science, innovation, and society. The conference, which might also be held in 1999, should take a fresh look at the ways in which appropriate scientific innovations can be nurtured in society. This much-needed overview would have to include an assessment of the current state of intellectual property protection.

Aside from the policy-laden issues discussed above, practical work is urgently needed in two closely-related areas.

5. Hidden, Lost, and Last Harvests: If there is modest progress for major world crops and livestock species, there is only the faint glimmer of awareness for the importance of

locally-significant food sources such as minor crops, crops that have been forcibly evicted from the marketplace, less-famous animal species, and, especially, the non-cultivated, but nurtured, fruits, vegetables, nuts, berries, and aquatic species, that can make the difference between life and death for hundreds of millions of people. Since the "Hidden Harvest" is not cultivated in the traditional sense, it has been almost completely ignored by FAO and discounted completely in its statistical studies. Logic dictates that the Convention on Biological Diversity should take the lead with respect to non-domesticated species and move to ensure their conservation and sustainable utilization. But time is wasting. There is a risk that the new Convention will move too slowly and fail to address the critically important contribution these species make to food security. There is a need and an opportunity for the CBD and FAO to cooperate. The Hidden Harvest must be fully integrated into FAO's food security agenda and into its post-Leipzig conservation work. The initiator and coordinator of this work must clearly be the Biodiversity Convention. It should also involve the fish and forest IARCs of the CG System, IPGRI, and UNESCO.

6. A Special Plea for Livestock: Notwithstanding our concern for the Hidden Harvest, there is a strong case to be made for emergency work on, and international support for, livestock genetic resources conservation. The pace of erosion is horrendous. Hundreds of millions of pastoralists and farming communities depend upon livestock for their survival. We must mount an effort at least equal to the work that has been done with respect to crops to conserve and develop livestock diversity. This is one area where civil society organizations should work closely with FAO, drawing attention to the crisis, and working with the Organization to arrest the destruction of animal diversity.

All of these recommendations lead to a final institutional proposal that arises quite naturally from Civil Society's experience with the UN System since the UNCED Conference in 1992. It is time to take another step in international cooperation.

7. A Global Forum on Food Security: We are living in a time when there is no money and less enthusiasm to take on substantive challenges. The work of the Biodiversity Convention in addressing agriculture; the Leipzig Process; and most especially the World Food Summit, have rekindled the world's concern for food and agriculture. But there is no new money and the path ahead is not yet clear. In Quebec City at the time of the FAO's Fiftieth Anniversary – and again in the NGO consultations in Rome prior to the Summit, civil society organizations called for a "New Roman Forum" or a Global Forum on Food Security that would bring all the actors around a common table every two years in a non-UN format. There needs to be a place where agribusiness, civil society organizations, governments, and multilateral institutions concerned with food and agriculture can meet, look for areas of cooperation, and make better use of their scarce resources. FAO offers a reasonable venue for such a Forum. The Global Forum could review progress by all parties, including industry and governments, on meeting the commitments of the Leipzig Plan of Action.

RAFI and many NGOs believe that the World Food Summit took a step forward when it agreed to convene a wide meeting of civil society organizations with the Committee on World Food Security prior to the mid-term review of the Summit Plan of Action (Commitment 7.3 (h)). As a follow-up to the 1996 Food Summit civil society organizations will continue to press for the Global Forum as expressed in Quebec City.

While it might be most appropriate for FAO to host the Forum, the responsibility for each meeting could rotate to other institutions. Besides a general review of progress toward food security, each Forum meeting could take on a specific theme, such as research or agricultural biodiversity. Participants would have two years to prepare for their contribution. Every effort would be made to ensure the active involvement of multilateral institutions such as the International Fund for Agricultural Development (IFAD), the World Food Programme (WFP), CGIAR, CBD, the United Nations International Children's Emergency Fund (UNICEF), World Bank, UNDP.

Would the Forum be yet another talk shop? There is that danger, of course. It could also go the way of the defunct World Food Council created following the 1974 World Food Conference. But that was a meeting of Ministers and, quite frankly, the world was not much interested in what they had to say. A configuration that brought together civil society and industry in direct dialogue with UN agencies and governments, as equals, would hardly be boring. If the discussion topics were targeted to areas of common concern and possible cooperation, the talk shop could lead to action. Food and agriculture would have a high-profile Forum that, over time, could become extremely influential. Multilateral institutions would ignore its discussions at their peril.

If useful, the Global Forum could not only rotate topics and chairs but also venue. As NGOs suggested in Rome in September 1996, UNICEF or CGIAR could host a biennial meeting.

Civil society organizations are not usually enthusiastic about bringing agribusiness to the table. The truth, of course, is that industry has access to many governments and UN fora anyway. As some have put it, it is better to have industry at the table than under it. Agribusiness has power. It is best to recognize it and deal with it directly.

The foregoing is not a complete or exclusive agenda. More could be said and new concerns and perspectives are unfolding all the time. This, too, is part of Human Nature.

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