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AGROBIODIVERSITY AND THE LAW

REGULATING GENETIC RESOURCES, FOOD SECURITY AND CULTURAL DIVERSITY

Juliana Santilli

AGROBIODIVERSITY AND THE LAW

A wide range of crop genetic resources is vital for future food security. Loss of agricultural biodiversity increases the risk of relying on a limited number of staple food crops. However, many laws, such as seed laws, plant varieties protection and access and benefit-sharing laws, have direct impacts on agrobiodiversity, and their effects have been severely underestimated by policy-makers. This is of concern not only to lawyers, but also to agronomists, biologists, and social scientists, who need clear guidance as to the relevance of the law to their work. This book analyzes the impact of the legal system on agrobiodiversity (or agricultural biodiversity) – the diversity of agricultural species, varieties, and ecosystems. Using an interdisciplinary approach, it takes up the emerging concept of agrobiodiversity and its relationship with food security, nutrition, health, environmental sustainability, and climate change. It assesses the impacts on agrobiodiversity of key legal instruments, including seed laws, the International Convention for the Protection of New Varieties of Plants, plant breeders' rights, the Convention on Biological Diversity (regarding specifically its impact on agrobiodiversity), and the International Treaty on Plant Genetic Resources for Food and Agriculture. It also reviews the options for the implementation of these instruments at the national level in several countries. It discusses the interfaces between the free software movement, the 'commons' movement, and seeds, as well as the legal instruments to protect cultural heritage and their application to safeguard agrobiodiversity-rich systems. Finally, it analyzes the role of protected areas and the possibility of using geographical indications to enhance the value of agrobiodiversity products and processes.

Juliana Santilli is a lawyer and public prosecutor in the Federal District of Brazil, specialized in Environmental and Cultural Heritage Law and Public Policies. She has a PhD in Environmental Law, and is an associate researcher in Environmental Law at the University of Brasília Center for Sustainable Development. She is a co-founding member of the Brazilian civil society organization Instituto Socioambiental.

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Juliana Santilli is the author of two books: *Socio-environmentalism and New Rights: Legal Protection of Biological and Cultural Diversity* (São Paulo: Peirópolis/ISA/IEB, 2005) and *Agrobiodiversity and Farmers' Rights* (São Paulo: Peirópolis, 2009). She has also organized and co-authored the book, *Indigenous Peoples and the Law* (Brasília: Núcleo de Direitos Indígenas). She has also published several articles on environmental and cultural heritage law and public policies, in Portuguese, English, French, and Spanish.

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She was the rapporteur of the Working Group on Traditional Knowledge and Biodiversity, created by the Brazilian Genetic Resources Management Council, which is responsible for the implementation of the Brazilian access and benefit-sharing national legislation (in accordance with the Convention on Biological Diversity). She was also a legal advisor for GTZ (now GIZ, the German Technical Cooperation) on legal issues relating to Indigenous peoples and environmental resources, in the context of the elaboration of the Indigenous component of the Pilot Programme for the Protection of Tropical Forests in Brazil (PP-G7), and a legal advisor for the World Wildlife Fund (WWF) in Brazil, advising on Environmental Law and Legal Protection to Brazilian Wetlands (Pantanal). She was also a legal advisor for the Green Protocol Program, developed by the Secretariat of Sustainable Development Policies/Ministry of Environment – Brazil.

Juliana is also a member of the council of the Brazilian civil society organization Instituto Internacional de Educação do Brasil (IEB; www.iieb.org.br).

PREFACE

Loss of agricultural diversity, at varying levels, is associated with the industrialization of agriculture, particularly after the Green Revolution, and cannot be attributed to legal systems only. However, many laws and regulations have direct impacts on agrobiodiversity, and these have been underestimated and sometimes not even considered by policy-makers and legislators. Agrobiodiversity and associated cultural diversity are major values that must be encompassed in all regulations that affect biological, genetic, and agroecosystem diversity.

The main objective of this book is to analyze the impacts that international and national legal instruments have on agrobiodiverse farming systems and on the local small-scale farmers who conserve and manage them. However, before analyzing legal instruments in themselves, we discuss what agrobiodiversity is, and show its important interfaces with food security, nutrition, health, social equity, environmental sustainability, and climate change. Understanding the multiple connections and implications of agrobiodiversity is essential to comprehend why it is so important that agricultural and rural development laws prioritize its conservation and sustainable use.

The book analyzes seed production, utilization, and sales laws, IP rights over plant varieties (and the so-called plant breeders' rights), farmers' rights, livestock keepers' rights, and access and benefit-sharing regulations and their impacts on plant and animal genetic resources for food and agriculture, among others. On the other hand, it shows that some legal tools that were not conceived primarily for agrobiodiversity conservation can also be used for this purpose, such as biological open source and creative commons, protected areas, and geographical indications. Positive and negative effects in different countries are also discussed.

We comprehend crops and agroecosystems as cultural artifacts, made and molded by man as much as ceramics, buildings, monuments, and other works of art. Therefore, the book discusses how legal instruments conceived to safeguard cultural heritage can also be used to recognize and promote agrobiodiverse farming systems and all of their components, both tangible (such as landscapes and cultivated plants) and intangible (agricultural techniques, practices, and knowledge), as well as the social and cultural processes that maintain and enrich them. Intangible cultural heritage registries and cultural landscapes recognition and protection, as well as the safeguarding of globally important ingenious agricultural heritage systems, are analyzed from the perspective of agrobiodiversity conservation and sustainable use.

Historically, public policies have focused mainly on wild biodiversity, and cultivated biodiversity has received very little attention not only from public officials but also from environmentalists, civil society organizations, and the general public. However, protecting species and varieties of maize, rice, beans, wheat, etc., as well as the diversity of agroecosystems, is no less important than saving the Amazon rainforest and threatened wild species such as panda bears, birds, turtles, etc. It is my sincere hope that this book will contribute to the development of more effective policies, legislation, and regulations governing *in situ* and on-farm management of agrobiodiversity, as well as for the protection of farmers' and livestock keepers' rights.

Juliana Santilli

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ACRONYMS AND ABBREVIATIONS

ABRASEM	Associação Brasileira de Sementes e Mudas (Brazilian Seeds and Seedlings Association)
ABS	access and benefit-sharing
AIAB	Associazione Italiana per l'Agricoltura Biologica
AS-PTA	Assessoria e Serviços a Projetos em Agricultura Alternativa (Advisory Services for Alternative Agriculture Projects, Brazilian NGO)
ASSINSEL	Association Internationale des Sélectionneurs pour la Protection des Obtentions Végétales (International Association of Plant Breeders for the Protection of Plant Varieties)
BIOS	Biological Open Source
BRG	Bureau des Ressources Génétiques (Genetic Resources Bureau, France, now extinct and merged into Fondation pour la Recherche sur la Biodiversité)
CBD	Convention on Biological Diversity
CGEN	Conselho de Gestão do Patrimônio Genético (Brazilian Council on Genetic Resources Management)
CGIAR	Consultative Group on International Agricultural Research
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIAT	International Center for Tropical Agriculture
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Center)
CIP	Centro Internacional de la Papa (International Potato Center)
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (Center of International Cooperation in Agricultural Research for Development, France)

CNPQ	Conselho Nacional de Desenvolvimento Científico e Tecnológico (Brazilian National Council for Scientific and Technological Development)
CNRS	Centre National de la Recherche Scientifique (National Center for Scientific Research, France)
CONAB	Companhia Nacional de Abastecimento (National Corporation for Food Supply, Brazil)
COP	Conference of the Parties (CBD)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Corporation for Agricultural Research)
EPAGRI	Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina (Company for Agricultural Research and Rural Extension of Santa Catarina, Brazil)
EPO	European Patent Office
ESA	European Seed Association
ETC Group	Action Group on Erosion, Technology and Concentration (formerly RAFI, Rural Advancement Foundation International)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FUNAI	Fundação Nacional do Índio (National Agency for Indigenous Affairs, Brazil)
GATT	General Agreement on Tariffs and Trade
GEF	Global Environment Facility
GIAHS	Globally Important Agricultural Heritage Systems
GMO	genetically modified organism
GNP	gross national product
GPA	Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture
GPL	General Public License
GPLPG	General Public License for Plant Germplasm
GRAIN	Genetic Resources Action International (NGO)
GTZ (now GIZ)	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)
IARC	International Agricultural Research Center
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute for the Environment and Renewable Natural Resources)
IBPGR	International Board for Plant Genetic Resources (later IPGRI, see below)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics

IEB	Instituto Internacional de Educação do Brasil (International Institute for Education, Brazilian NGO)
IFPRI	International Food Policy Research Institute
IICA	Instituto Interamericano de Cooperação para a Agricultura (Interamerican Institute for Cooperation in Agriculture)
IITA	International Institute of Tropical Agriculture
ILO	International Labor Organization
ILRI	International Livestock Research Center
IRRI	International Rice Research Institute
INIA	Instituto Nacional de Innovacion Agraria (National Institute for Agrarian Innovation)
INPI	Instituto Nacional de Propriedade Industrial (National Institute for Industrial Property, Brazil)
INRA	Institut National de la Recherche Agronomique (National Institute for Agricultural Research, France)
IOM	International Organization for Migration
IPAM	Instituto de Pesquisa Ambiental da Amazônia (Institute for Environmental Research of the Amazon, Brazil)
IPCC	Intergovernmental Panel on Climate Change
IPGRI	International Plant Genetic Resources Institute (now Bioversity International)
IPHAN	Instituto do Patrimônio Histórico e Artístico Nacional (Institute for National Historical and Artistic Heritage, Brazil)
IP	intellectual property
IRD	Institut de Recherche pour le Développement (Institute of Research for Development, France)
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
ISA	Instituto Socioambiental (Socioenvironmental Institute, Brazilian NGO)
IUCN	International Union for Conservation of Nature
MAPA	Ministério da Agricultura, Pecuária e Abastecimento (Brazilian Ministry of Agriculture, Livestock and Food Supply)
MDA	Ministério do Desenvolvimento Agrário (Brazilian Ministry of Agrarian Development)
MDG	Millennium Development Goal
MNHN	Muséum National d'Histoire Naturelle (National Museum of Natural History)
MPEG	Museu Paraense Emílio Goeldi (Emilio Goeldi Museum of Pará, Brazil)
NGO	nongovernmental organization

NordGen	Nordic Genetic Resource Center
PAA	Programa de Aquisição de Alimentos (Food Acquisition Program, Brazil)
PGRFA	plant genetic resources for food and agriculture
PVPA	Plant Variety Protection Act
PRONAF	Programa Nacional de Fortalecimento da Agricultura Familiar (National Program to Strengthen Family Agriculture, Brazil)
RENASEM	Registro Nacional de Sementes e Mudas (National Seeds and Seedlings Registry, Brazil)
SMTA	standard material transfer agreement
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNDRIP	UN Declaration on the Rights of Indigenous Peoples
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	UN Framework Convention on Climate Change
UNICAMP	Universidade Estadual de Campinas (State University of Campinas, Brazil)
UPOV	Union pour la Protection des Obtentions Végétales (Union for the Protection of New Varieties of Plants)
USDA	United States Department of Agriculture
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
WWF	Worldwide Fund for Nature

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AGROBIODIVERSITY

A concept under construction

The concept of "agrobiodiversity" emerged in the past 10–15 years, in an interdisciplinary context that involves various areas of knowledge (agronomy, anthropology, ecology, botany, genetics, conservation biology, etc.). It reflects the dynamic and complex relations among human societies, cultivated plants, and domestic animals and the ecosystems in which they interact. Agrobiodiversity is directly associated with food security, health, social equity, hunger alleviation, environmental sustainability, and rural sustainable development.

Biodiversity or biological diversity – the diversity of life forms – covers three degrees of variability: diversity of species, genetic diversity (variability within the set of individuals of a given species), and ecological diversity, referring to different ecosystems and landscapes. The same is true of agrobiodiversity, which comprises the diversity of species (different species of cultivated plants, such as maize, rice, pumpkins, tomatoes, etc., called interspecific diversity), genetic diversity within a given species (different varieties of maize or beans, etc., called intraspecific diversity), and the diversity of cultivated ecosystems or agroecosystems[1] (agroforestry systems, shift cultivation, home gardens, rice paddy fields, etc.). Local knowledge and culture are also integral parts of agricultural biodiversity, since it is agriculture, a human activity, that conserves biodiversity. Most crops have lost their original seed dispersal mechanisms as a result of domestication and so can no longer thrive without human input (Cromwell *et al.*, 2003). Agrobiodiversity, or agricultural diversity, is an important part of biodiversity and encompasses all the elements which interact in agricultural production, including all crops and livestock and their wild relatives, and all interacting species of pollinators, symbionts, parasites, pests, predators, and competitors, and the genetic diversity within them (Qualset *et al.*, 1995). According to Cromwell *et al.* (2003), agricultural biodiversity includes (1) higher plants: crops, wild plants harvested and managed for food, trees on farms, and pasture and rangeland species; (2) higher animals: domestic animals, wild animals hunted for food, etc., wild and farmed fish; (3) arthropods: mostly insects including pollinators (e.g., bees, butterflies), pests (e.g., wasps, beetles), and insects involved in the soil cycle (notably termites); (4) other macro-organisms (e.g., earthworms); (5) micro-organisms (e.g., rhizobia, fungi, disease-producing pathogens). Agrobiodiversity's functions are related to sustainable production of food and other agricultural products, including providing the building blocks for the evolution or deliberate breeding of useful new crop varieties; biological support to production by means of, for example, soil biota, pollinators, and predators; and wider ecological services provided by agroecosystems, such as landscape protection, soil protection and health, water cycling and quality, and air quality (Cromwell *et al.*, 2003).

According to Harold Brookfield (2001, p. 46), agrobiodiversity is the "dynamic variation in cropping systems, output and management practice that occurs within and between agroecosystems. It arises from biophysical differences, and from the many and changing ways in which farmers manage diverse genetic resources and natural variability, and organize their management in dynamic social and economic contexts." Brookfield (2001, p. 41) defines management diversity as all methods of managing the land, water, and biota for crop production and maintaining soil fertility and structure. Local knowledge, constantly modified by new information, is the foundation of this management diversity, as with agrobiodiversity. For Brookfield (2001, p. 41), biophysical diversity includes soil characteristics and their qualities and the biodiversity of natural (or spontaneous) plant life and the faunal and microbial biota. Organizational diversity is often called the socioeconomic aspect of agriculture. It includes diversity in the manner in which farms are owned and operated and in the use of resource endowments and the farm workforce. Elements include labor, household size, the differing resource endowments of households, and reliance on off-farm employment. Also included are age group and gender relations in farm work, dependence on the farm as compared with external sources of support, the spatial distribution of the farm, and differences between farmers in terms of access to land. Organizational diversity underpins and helps explain management diversity and its variation between particular farms, communities, and societies. According to Brookfield (2001, p. 44), no agricultural system can be understood independently from the manner in which farms are organized and the forces that interact to shape this organization.

Agrobiodiversity is generally associated with crops (cultivated plants). However, Cromwell *et al.* (2003) point out that wild species[2] are important nutritionally and culturally. Foods from wild species form an integral part of the daily diets of many rural households. Livestock diversity is also an important component of agrobiodiversity. Domesticated animals provide people not only with food but also with clothing, fertilizer and fuel (from manure), and draft power. Social and cultural forces are often the most important factors in diversifying livestock (and livestock production systems) and in developing distinctive breeds. Most local livestock breeds in rural environments are products of a community of breeders, and the effective management of animal genetic diversity is essential to global food security and sustainable development.

The Food and Agriculture Organization's (FAO's) Global Databank for Animal Genetic Resources for Food and Agriculture identified a total of 7,616 livestock breeds. Such diversity has enabled farmers and pastoralists to adapt to local environmental conditions and to meet specific social and cultural needs, as well as to inhabit a wide range of production environments from hot humid tropics to arid deserts and cold mountainous regions. Genetic diversity also allows livestock to adapt to diseases, parasites, and wide variations in the type and availability of food and water. Yet livestock diversity is at risk. According to the *Report on the State of the World's Animal Genetic Resources for Food and Agriculture*,[3] approximately 20 percent of the cow, goat, pig, horse, and bird breeds in the world are threatened with extinction, and in the past six years 62 breeds of domestic animals have become extinct, which represents a loss of nearly one race per month. In 2000, FAO (FAO, 2000) estimated that, of the 3,831 breeds of cows, buffalo, goats, pigs, sheep, horses and donkeys believed to have existed in the twentieth century, 16 percent had already become extinct and a further 15 percent were at risk of extinction. The most significant threat to livestock diversity is the marginalization of traditional production systems and the associated local breeds, driven mainly by the rapid spread of intensive livestock production, often large-scale and utilizing a narrow range of breeds (*Report on the State of the World's Animal Genetic Resources for Food and Agriculture*).

Cromwell *et al.* (2003) also highlight the importance of aquatic diversity as a component of agrobiodiversity. Fish and other aquatic species are integral parts of several important farming systems. For example, in the tropical rice–fish systems of Asia, fish from rice paddies may provide as much as 70 percent of dietary protein. Another important component of agrobiodiversity is the underground biodiversity: roots bring nutrients and water to plants and stabilize the soil against erosion and soil movement on steep slopes and, in tropical systems, the contribution of roots to soil organic matter is proportionately larger than the contribution from above-ground inputs. Microbial diversity is also relevant to agricultural biodiversity, as microbes contribute a wealth of gene pools that can be sources of material for transfer to plants to achieve traits such as stress tolerance and pest resistance, and large-scale production of plant metabolites. The diversity of insects (such as bees and other pollinators), spiders, and other arthropods (grasshoppers, etc.) is another important component of agrobiodiversity, since they often act as natural enemies of crop pests. Finally, there is increasing realization of the importance of agricultural biodiversity at the ecosystems level. An ecosystem consists of a dynamic complex of plant, animal and micro-organism communities and their living environment interacting as a functional unit. That is why agrobiodiversity at the ecosystems level is sometimes referred to as "functional agricultural biodiversity": that which is necessary to sustain the ecological function of the agroecosystem, its structures, and processes in support of food production (Cromwell *et al.*, 2003). In this book, we shall focus mainly on the diversity of cultivated plants and agroecosystems, and on livestock diversity, more than on other components of agricultural biodiversity, since they are the mostly regulated components of agricultural biodiversity, and the purpose of the book is to analyze impacts of legal instruments on agrobiodiversity.

The Convention on Biological Diversity (CBD)[4] does not contain a definition of agrobiodiversity, but, according to Decision V/5, adopted during the Fifth Conference of the Parties of CBD (COP-5), "agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agroecosystem: the variety and variability of animals, plants and microorganisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agroecosystem, its structure and processes." Agricultural biodiversity has the following dimensions (according to Decision V/5):

1 Genetic resources for food and agriculture, including (a) plant genetic resources, including pasture and rangeland species, and genetic resources of trees that are an integral part of farming systems; (b) animal genetic resources, including fishery genetic resources, in cases where fish production is part of the farming system, and insect genetic resources; and (c) microbial and fungal genetic resources. These constitute the main units of production in agriculture, including cultivated species, domesticated species, and managed wild plants and animals, as well as wild relatives of cultivated and domesticated species.
2 Components of agricultural biodiversity that provide ecological services. These include a diverse range of organisms in agricultural production systems that contribute, at various scales, to *inter alia*: (a) nutrient cycling, decomposition of organic matter and maintenance of soil fertility; (b) pest and disease regulation; (c) pollination; (d) maintenance and enhancement of local wildlife and habitats in their landscape; (e) maintenance of the hydrological cycle; (f) erosion control; and (g) climate regulation and carbon sequestration.
3 Abiotic factors which have a determining effect on these aspects of agricultural biodiversity.
4 Socioeconomic and cultural dimensions, since agricultural biodiversity is largely shaped by human activities and management practices. These

include (a) traditional and local knowledge of agricultural biodiversity, cultural factors, and participatory processes; (b) tourism associated with agricultural landscapes; and (c) other socioeconomic factors.

It is important to understand that a domesticated plant is not the same as a cultivated plant. Ethnobotanist Laure Emperaire (2004) explains that domestication is an evolutionary process through which a plant moves from its wild state – in which there is no human intervention – to a closer relation with humans and their agricultural activities. Domestication requires modification in the genetic heritage (composition) of the plant. As a result of selective cultivation by man, domesticated plants lose certain characteristics (which are not interesting for agricultural activities) and develop others. Some characteristics of domesticated plants include gigantism (especially of parts of the plant of interest to humans), suppression of natural mechanisms of seed dispersion, rapid and uniform seed germination, etc. Therefore, cultivated plants are not necessarily domesticated, but domesticated plants are necessarily cultivated (Emperaire, 2004). In other words, wild plants can be cultivated without being domesticated, but the inverse is not true: domesticated plants cannot be abandoned in unmanipulated landscapes because they have lost their ecological adaptations to natural environments.

Jack Harlan (1975) explains that "to domesticate means to bring into the household." According to Harlan (1975), domesticated plants and animals have been altered genetically from their wild state and have come to be at home with man. He explains that to cultivate means to conduct those activities involved in caring for a plant, such as tilling the soil, preparing a seedbed, weeding, pruning, protecting, watering, and manuring. Cultivation is concerned with human activities, whereas domestication deals with the genetic response of the plants or animals being tended or cultivated. It is therefore possible to cultivate wild plants, and cultivated plants are not necessarily domesticated. Harvested plant materials may be classified as wild, tolerated, encouraged and domesticated (Harlan, 1975).

According to Charles Clement (1999), plant domestication is a "co-evolutionary process by which human selection on the phenotypes of promoted, managed or cultivated plant populations results in changes in the population's genotypes that make them more useful to humans and better adapted to human intervention in the landscape." Human selection may be either unconscious or directed, but for plant domestication to take place there must be selection and management to cause differential reproduction and survival. According to Clement (1999), the degree of change in the targeted population can vary:

1. *Wild*. A naturally evolved population whose genotypes and phenotypes have not been modified by human intervention.

2 *Incidentally co-evolved*. A population that volunteers and adapts in a human disturbed environment, possibly undergoing genetic change, but without human selection. Many weeds are examples of incidentally co-evolved species, which can also enter the domestication process if humans start to select them for their useful traits and start to manage or cultivate them.
3 *Incipiently domesticated*. A population that has been modified by human selection and intervention (at the very least being promoted), but whose average phenotype is still within the range of variation found in the wild population for the trait(s) subject to selection. The variance of this average is probably smaller than that of the original wild population, however, as selection has started to reduce genetic variability.
4 *Semidomesticated*. A population that is significantly modified by human selection and intervention (at the very least being managed) so that the average phenotype may diverge from the range of variation found in the wild population for the trait(s) subject to selection. The variance of this phenotypic average may be larger than that of the wild population, because the phenotypic variation now includes both types that are common in the wild population and types that are novel. Underlying genetic variability, however, continues to decrease because fewer individuals meet the selection criteria and are therefore included in the next generation. The plants retain sufficient ecological adaptability to survive in the wild if human intervention ceases, but the phenotypic variation selected by humans will gradually disappear in the natural environment.
5 *Domesticated*. A plant population similar to those semidomesticated, but whose ecological adaptability has been reduced to the point that it can only survive in human-created environments, specifically in cultivated landscapes. Genetic variability is generally less than in semidomesticated plant populations, because of increased selection pressure and loss of ecological adaptation. If human intervention ceases, the population dies out in short order, depending upon its life history, stature, and the type of vegetation that invades the abandoned area. In clonally propagated crops, a single genotype may be the domesticate, but also is lost soon after it is abandoned.

Clement (1999) also describes “landscape domestication” as “a conscious process by which human manipulation of the landscape results in changes in landscape ecology and in the demographics of its plant and animal populations, resulting in a landscape more productive and congenial for humans.” According to him, the intensity of manipulation may also vary widely:

1 *Pristine*. A landscape in which humans have not manipulated plant or animal populations.

2 *Promoted*. In this category desirable plant populations and individuals are encouraged through minimal forest clearance and expansion of the forest fringes. Even though there may have been a low level of human intervention, the biotic components of this landscape may remain modified long after humans have abandoned the area.
3 *Managed*. In this category the abundance and diversity of food and other useful plant populations may be further encouraged through partial forest clearance, expansion of the forest fringes, transplanting of desirable individual plants or planting of individual seeds, addition of amendments to enhance plant growth, and reduction of competition from nonuseful plants. Again, the biotic components of this landscape may remain long after humans have abandoned the area.
4 *Cultivated*. This category involves the complete transformation of the biotic landscape to favor the growth of one or a few selected food plants and other useful populations, through forest clearance and burning, localized or extensive tillage, seedbed preparation, weeding, pruning, manuring, mulching, and watering in any combination. The biotic components of this very artificial landscape do not survive long after human abandonment because the changes that favor the growth of the human selected populations also favor the growth of weeds and the invasion of other secondary forest species; however, it takes a long time to return to a natural state. The abiotic transformations practiced in this landscape often survive for long periods.

According to Decision V/5 of CBD, the special nature of agricultural biodiversity includes the following features:

a Agricultural biodiversity is essential to satisfy basic human needs for food and livelihood security.
b Agricultural biodiversity is managed by farmers. Many components of agricultural biodiversity depend on this human influence. Indigenous knowledge and culture are integral parts of the management of agricultural biodiversity.
c There is a great interdependence among countries on the genetic resources for food and agriculture.
d For crops and domestic animals, diversity within species is at least as important as diversity between species and has been greatly expanded through agriculture.
e Because of the degree of human management of agricultural biodiversity, its conservation in production systems is inherently linked to sustainable use.
f Nonetheless, much biological diversity is now conserved *ex situ* in genebanks or breeders' materials.

g The interaction between the environment, genetic resources and management practices that occurs within agroecosystems contributes to maintaining dynamic agricultural biodiversity.

Although the terms "agrobiodiversity" and "agrodiversity" are often employed as synonyms, Brookfield and Stocking (1999) hold that agrobiodiversity and agrodiversity have different meanings. "Agrobiodiversity," an older and more common term, is used to define the biological diversity existing in cultivated ecosystems. "Agrodiversity" is a broader expression, employed to refer to the many forms with which farmers use the natural diversity of the environment for agricultural production, including not only the selection of plant species and varieties for cultivation, but also management of the soil, water and biota as a whole (Brookfield and Paddoch, 1994). Another definition of "agrodiversity" could be "the variety resulting from the interaction among the factors which determine agroecosystems: genetic resources of plants, biotic and abiotic environments and management practices" (Almekinders *et al*., 1995). We prefer to use "agrobiodiversity."

Agrobiodiversity is essentially a product of human intervention on ecosystems, of man's inventiveness and creativity in the interaction with the natural environment. Cultural processes, knowledge, and innovations, developed and shared by farmers, are a key component of agrobiodiversity. Species management, cultivation, and selection practices developed by farmers throughout the past 10,000 to 12,000 years are responsible, in large part, for the enormous diversity of cultivated plants and agroecosystems. All over the world, farmers innovate, experiment, and learn to adapt and diversify agricultural practices, and knowledge about biodiversity is closely tied to diverse and dynamic cultural beliefs, customs, and practices. Therefore, agrobiodiversity cannot be treated separately from the cultural and socioeconomic processes and contexts which determine it.

According to Brookfield (2001, pp. 21, 286) the adaptive dynamism of agrobiodiversity is its most essential property for survival, and for restoration of what has been lost. "Centrally important (to agrobiodiversity) is the internal dynamism of so many small-farming systems, yielding a constantly changing patchwork of relationships between people, plants and the environment," according to him.

Farmers adapt to difficulties and to opportunities, and learning and experimenting processes are constantly renewed. There are societies that adapt rice varieties to aquatic cultivation, submerged in water, in humid regions, while others adapt rice varieties for cultivation in dry regions. Different varieties of maize can be used for eating directly from the cob, for feeding animals, for making popcorn and flour, or to brew beer. They can also be used for ornamental (especially those with colorful pigmentation), medicinal, or religious purposes. Agronomist Jack Harlan (1975, p. 164) says that he once noticed that an Ethiopian farmer selected crook-necked sorghum varieties from his field. On asking the farmer the reason for this, he replied that such varieties were easier to hang from the tukel roof. (In Ethiopia, it is common to store seed inside the house [tukel] above the hearth, where the smoke from the kitchen fires provides some protection from weevils.) Other farmers selected sorghum varieties with a sweet taste for chewing. Other varieties of sorghum were set apart for making bread and beer, and the varieties with more resistant fibers were used to make baskets and as construction materials. The same species can be used for food or medication, and different parts of the same plant can also serve distinct purposes. Plants are also used in religious rituals and ceremonies, and many different names may be given to the same species by different local communities. Agricultural diversity can also be expressed both in characteristics visible to the human eye, such as variations in color, shape, or height or in the size and shape of the leaves, and in genetic variations, such as resistance to droughts, pests, and diseases, nutritional value, etc., and losses are hard to assess with precision. Extinction of agricultural knowledge is even harder to assess.

Even if the losses cannot be precisely estimated, agricultural diversity is threatened, and it constitutes the basis for survival of rural populations, particularly those of lower income. The *First Report on the State of the World's Plant Genetic Resources for Food and Agriculture*, presented during the Fourth International Technical Conference on Plant Genetic Resources, held in Leipzig, Germany, from June 17 to 23, 1996, was an important warning for the genetic and cultural erosion provoked by modern agricultural systems. The report, published by FAO in 1998, was the first global and systematic assessment of the state of conservation and use of global plant genetic resources. According to the report, in the past hundred years, farmers lost between 90 percent and 95 percent of their agricultural varieties. The report goes further:

1 In South Korea, only one-fourth of the 14 native plant varieties grown in gardens in 1985 were still in existence in 1993. Only 20 percent of maize varieties which existed in Mexico in the 1930s exist today.
2 In the United States, 95 percent of cabbage varieties, 94 percent of pea varieties, and 81 percent of tomato varieties ceased to exist in the past century. Of the 7,098 varieties of apples in existence between 1804 and 1904, 86 percent no longer exist.
3 In China, of the 10,000 varieties of wheat used in 1949, only 1,000 were still used in the 1970s. Up until the 1970s, approximately 5,000 rice varieties were grown in India, of which only 500 still exist, and between 10 and 20 varieties take up most of the Indian farmland.

Loss of agricultural biodiversity is caused mainly by the replacement of local and traditional varieties, which are characterized by large genetic variability, by "modern" varieties, with high yields and narrow genetic bases. According to the report, this is the main cause of genetic erosion (mentioned in 81 percent of the national reports presented by participating countries). Both species and varieties derived from these species have disappeared, and this is not limited to species domesticated by humans, as wild relatives continue to disappear as a result of rapid devastation of natural ecosystems. In some cases, disappearance of a variety may not necessarily lead to loss of genetic diversity, as its genes may exist in other varieties as well, but varieties themselves represent a unique combination of genes, with equally unique value and utility. It is also estimated that loss of a plant can cause disappearance of 40 types of animals and insects that depend on it for survival, in addition to singular genetic combinations and molecules (Kloppenburg and Kleinman, 1987).

The *Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture* was launched by FAO in 2009, and published in 2010.[5] Its main objective was to update the first report, to assess the status and trends of plant genetic resources and to identify the most significant gaps and needs. It was prepared with information provided by 113 countries, and was the basis for updating the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. It describes the most significant changes that have occurred since the publication of the first report in 1998.[6]

According to the second report, much more consensus exists on the occurrence of genetic erosion as a result of the total shift from traditional production systems (depending on farmers' varieties) to modern production systems (depending on released varieties), and major causes of genetic erosion were the same as identified in the first report: replacement of local varieties, land clearing, overexploitation, population pressures, environmental degradation, changing agricultural systems, overgrazing, and inappropriate legislation and policy, as well as pests, diseases, and weeds. However, the report points out that more attention is now being paid in several countries to increasing genetic diversity within production systems as a way to reduce risk, particularly in light of changes in climate, pests, and diseases. According the the second report, significant progress has also been made in the development of tools and techniques to assess and monitor plant genetic resources for food and agriculture (PGRFA) within agricultural production systems, and countries now report a greater understanding of the amount and distribution of genetic diversity in the field, as well as the value of local seed systems in maintaining such diversity.

According to the report, 60 countries state that genetic vulnerability is significant, and many mention the need for a greater deployment of genetic diversity in order to counter the potential threat to agricultural production. However, the report points out that the true extent of genetic erosion is very complex to assess. Some examples of genetic erosion mentioned in the report are:

- In Benin, there is concern that the current agricultural system is dominated by monocultures, in particular of yam and commercial crops.
- China has reported cases in which rice and maize varieties have become more uniform and thus more genetically vulnerable.
- Ecuador reports that endemic plants are particularly vulnerable owing to their restricted distribution. In the Galapagos Islands, at least 144 species of native vascular plants are considered rare; 69 of these are endemic to the Archipelago, including 38 species which are restricted to a single island.
- In Lebanon, the decrease in national production of almonds has been attributed to the genetic vulnerability of the few varieties grown.
- Madagascar has reported that the rice variety Rojomena, appreciated for its taste, is now rare, whereas the Botojingo and Java varieties of the northeastern coastal area have disappeared. The cassava variety Pelamainty of Taolagnaro (a city in Madagascar) and certain varieties of bean have disappeared from most producing areas and, in the case of coffee, 100 clones out of 256, as well as five species (*Coffea campaniensis*, *C. arnoldiana*, *C. rostandii*, *C. tricalysioides*, and *C. humbertii*) have disappeared from collections in the last 20 years. Wild yam species are also considered likely to disappear soon.
- Costa Rica reports that *Phaseolus* spp. (beans), including *P. vulgaris*, are threatened by serious genetic erosion; the same is true of the Indigenous crop *Sechium tacaco* and four related species: *S. pittieri*, *S. talamancense*, *S. venosum*, and *S. vellosum*.
- In India, a large number of rice varieties in Orissa, some rice varieties with medicinal properties in Kerala, and a range of millet species in Tamil Nadu, are no longer cultivated in their native habitats.
- Yemen reports that varieties of finger millet (*Eleusine coracana*) and *Eragrostis tef* as well as oil rape (*Brassica napus*), which used to be among the most important traditional crop varieties grown in the country, are no longer grown or are grown only in very specific areas and that the cultivation of wheat, including *Triticum dicoccum*, has drastically decreased.
- In Albania, all primitive wheat cultivars and many maize cultivars, have reportedly been lost.

Other major conclusions of the second report are:

- The total number of accessions conserved *ex situ* worldwide has increased by approximately 20 percent since 1996, reaching 7.4 million. While new collecting accounted for at least 240,000 accessions, and possibly considerably more, much of the overall increase is the result of exchange and unplanned duplication. It is estimated that less than 30 percent of the total number of accessions are distinct. Although the number of accessions of minor crops and crop wild relatives has increased, these categories are still generally under-represented. There is still a need for greater rationalization among collections globally.

- Scientific understanding of the on-farm management of genetic diversity has increased. The number of on-farm management projects carried out with the participation of local stakeholders has also increased somewhat. Although this approach to the conservation and use of PGRFA is becoming increasingly mainstreamed within national programs, further efforts are needed in this regard.
- In many countries public sector plant breeding has continued to contract, with the private sector increasingly taking over. Agriculture in many developing countries that reduced their support to public sector crop development, leaving, instead, the sustainable use of PGRFA to the private sector, is more vulnerable than in the past as private sector breeding and seed enterprise is largely restricted to a few crops for which farmers buy fresh seed each season. Considerably more attention and capacity-building is urgently needed to strengthen plant breeding capacity and the associated seed systems in most developing countries, where most of the important crops are not, and will not be, the focus of private enterprise.

Finally, it is important to stress that agrobiodiversity is valuable not only for small-scale traditional farming, but also for large-scale commercial production systems. Genetic diversity (including the genes of wild relatives) continues to be vital for modern agriculture, plant and livestock breeding, and for new methods of bioengineering and biotechnology. Increasing numbers of large commercial producers are also beginning to recognize and profit from the benefits of agroecosystem diversity, such as using intercropping and crop rotation and enhancing soil and insect diversity, and examples can be found among major producers of grapes, vegetables, and rice in Europe, the United States, and parts of Asia. These producers generally are motivated to try such changes after experiencing significant losses with monocultural, uniform systems (Thrupp, 1998, pp. 19–20). Biodiversity is essential to any agricultural system, and to ecological stability.

Notes

1 According to Conway (1987), an agroecosystem is an ecological and socioeconomic system, comprising domesticated plants and/or animals and the people who husband them, intended for the purpose of production of food, fiber, or other agricultural products.

2 Wood and Lenné (1999) exclude wild plants and animals outside the agroecosystem. According to them, although such wild food is often of critical importance to farm families, it is not part of the farm and is not agrobiodiversity.

3 The *State of the World's Animal Genetic Resources for Food and Agriculture* is the first global assessment of livestock biodiversity. It was announced during the First International Technical Conference on Animal Genetic Resources for

Food and Agriculture, held in Interlaken, Switzerland, between December 3 and 7, 2007, (http://www.fao.org/docrep/010/a1260e/a1260e00.HTM, accessed December 15, 2010).

4 The Convention on Biological Diversity (CBD) was approved during the Second Conference of the United Nations on Environment and Development, held in Rio de Janeiro in 1992. It entered into force on December 29, 1993, and has three main objectives: conservation of biological diversity, sustainable use of the components of biological diversity, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. The Fifth Conference of the Parties of the CBD was held in Nairobi between May 15 and 26, 2000 (http://www.cbd.int/decision/cop/?id=7147; accessed December 10, 2010). Other decisions relevant to agricultural biodiversity are COP 10 Decision X/34, COP 8 Decision VIII/23, COP 7 Decision VII/3, COP 6 Decision VI/5, COP 5 Decision V/5, COP 4 Decision IV/6, and COP 3 Decision III/11 (http://www.cbd.int/agro/decisions.shtml; accessed December 10, 2010).

5 The *Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture* is divided into eight chapters, which address the state of diversity; the state of *in situ* management; the state of *ex situ* conservation; the state of use; the state of national programs, training needs, and legislation; the state of regional and international collaboration; access to plant genetic resources, the sharing of benefits arising out of their utilization and the realization of farmers' rights; and the contribution of plant genetic resources to food security and sustainable agricultural development (http://www.fao.org/docrep/013/i1500e/i1500e00.htm; accessed December 15, 2010).

6 As a strategic framework, the Global Plan of Action needs to be periodically reviewed and updated. An updated version of the Global Plan of Action was approved by the Commission on Genetic Resources for Food and Agriculture in July 2011, based primarily on the gaps and needs identified in the Second Report, and in the light of new challenges such as climate change.

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