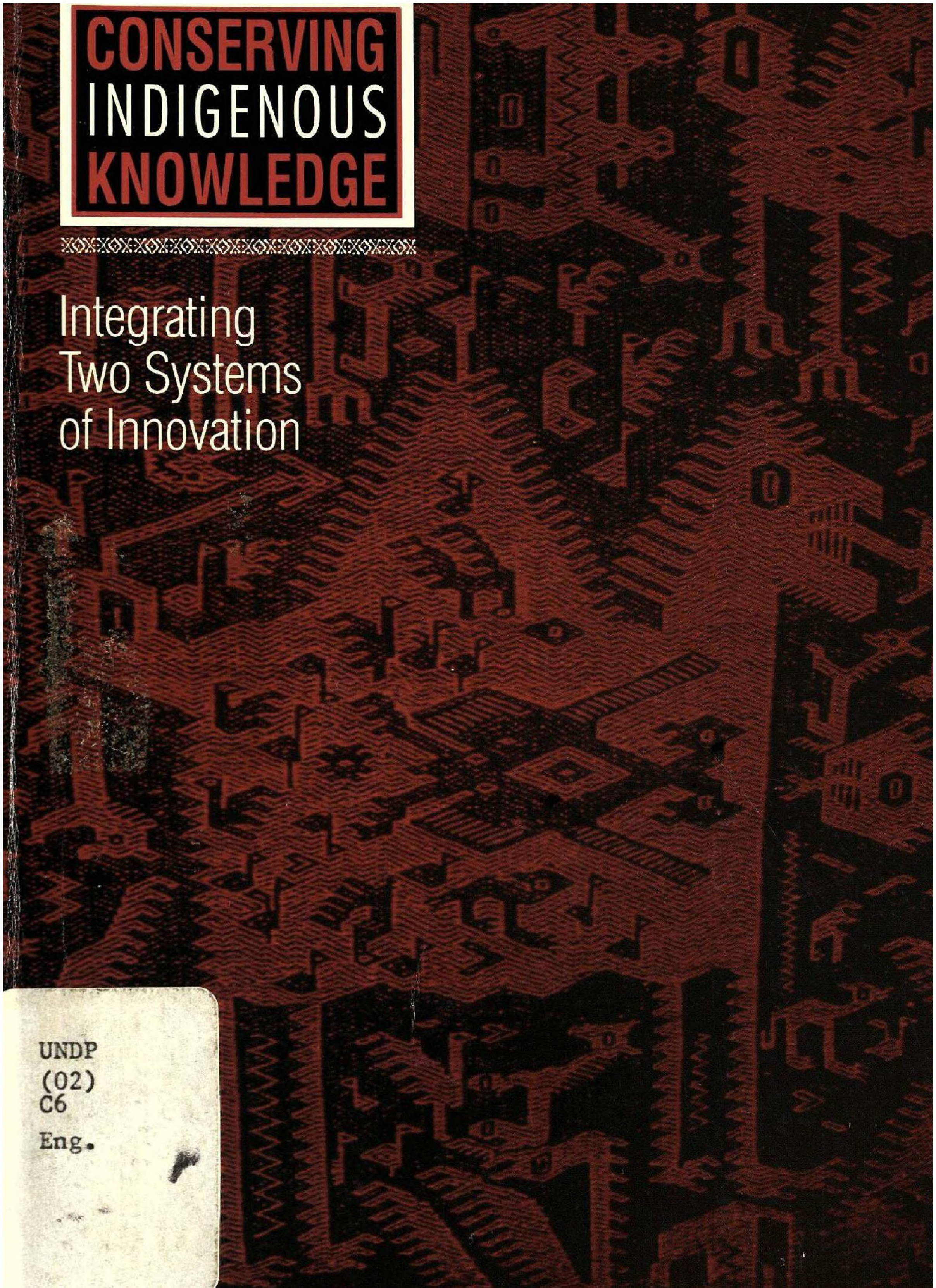
CONSERVING INDIGENOUS KNOWLEDGE

Integrating Two Systems of Innovation



An independent study by the Rural Advancement Foundation International
Commissioned by the United Nations Development Programme

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FOREWORD

Only a few decades ago, indigenous people were largely considered a "hindrance" to development. They were seen as part of a backward, pre-industrial traditional sector whose interests, especially in the case of land rights, were in conflict with the interests of the modern, industrial sector of society.

The concept of sustainable development (i.e., development that meets present needs without compromising the options of future generations), brought development and environment into one logical framework. It was an "ideological bridge" between the traditional and the modern sectors by recognizing the significance of indigenous people's holistic knowledge of the environment and management of natural resources.

A sharp deterioration in living conditions, especially in Africa and Latin America, the failure of traditional development strategies and the growing influence of non-governmental and community-based organizations brought home the fact that, for development to succeed, "beneficiaries" of programmes must also be closely involved in their design and implementation.

Recognition of these ideas within the United Nations Development Programme (UNDP) has resulted in the emerging concept of sustainable human development, which regards people as both the means and end of social and economic policies. It sees development as a process that must enlarge the range of people's choices, and enable them to participate in the decisions which affect their lives. Sustainable human development is inclusive and, necessarily, multisectoral.

The importance of both of these concepts was reflected in the adoption of *Agenda 21* at the United Nations Conference on Environment and Development in 1992. In chapter 26, "Recognizing and strengthening the role of indigenous people and their communities," *Agenda 21* calls for "*recognition of their values, traditional knowledge and resource management practices with a view to promoting environmentally sound and sustainable development,*" and for the "*establishment ... of arrangements to strengthen the active participation of indigenous people and their communities in the national formulation of policies, laws and programmes relating to resource management and other development processes that may affect them, and their initiation of proposals for such policies and programmes.*"

The unique role of indigenous people is not limited to the conservation of the Earth's biodiversity. A large segment of the world's population depends on indigenous knowledge for food and health care. The Rural Advancement Foundation International (RAFI) estimates in this report that "80 percent of the world's people continue to rely upon indigenous knowledge for their medical needs and possibly two thirds of the world's people could not survive without the foods provided through indigenous knowledge of plants, animals, insects, microbes and farming systems." As the potential for expanded irrigation and the use of fertilizers and pesticides shrinks, improving the livelihoods of millions of people, or even maintaining the present level, will depend ever more on traditional production systems.

Indigenous communities have made and continue to make important contributions to industrial agriculture, the pharmaceutical industry and biotechnology. Among the most famous examples are the skeletal muscle relaxant d-tubocurarine, which is derived from the Amazonian arrow poison known as curare, and the antimalarial drug quinine, which is made out of the bark of cinchona trees. Rapid scientific progress in genetic engineering will probably increase the demand for plants, animals and fungi developed, nurtured, or known by indigenous communities.

Recognition of the role of indigenous knowledge in these fields is crucial. As argued in this report, indigenous knowledge has not been the result of passive accumulation. On the contrary, it is the result of a dynamic "cooperative innovation system" that continues to work and continues to offer humankind hope for planetary survival. To destroy or ignore this system would be a dangerous mistake. It would deprive the world of one of its main sources of innovation and diversity.

Greater recognition of the importance of the cooperative innovation system could also play a role in improving the livelihoods of indigenous communities. In a report to the Secretariat of the United Nations Conference on Environment and Development, Daniel Matenho Cabixi wrote: "*Indigenous cultures offer a rich and unexploited source of information about the natural resources of the Amazon Basin. Could this knowledge be transmuted into modern technological know-how, a new path for the ecologically-sound development of Amazonia would have been found. In the same way, if technological civilization starts to understand the richness and complexity of indigenous knowledge, the Indians could be equalled to any human being, and no longer seen just as exotic footnotes of History.*"

With this publication, UNDP hopes to raise awareness of the value of traditional knowledge, not only for indigenous communities — who often depend on this knowledge for their own nutrition, health and agriculture — but also for the world at large. We hope to begin a dialogue with indigenous communities and others — multilateral, bilateral, governmental and nongovernmental development partners, academic institutions and private sector organizations — on ways to preserve this knowledge. Our aim is to ensure that, in the future, indigenous communities will, on their own terms, benefit from any commercialization of products of their knowledge, and avoid becoming trapped in a system of exploitation. This report presents a viewpoint that has not yet received wide exposure. As such, we hope it will prompt debate on these important issues.

Based on this publication, UNDP will begin a process of consultations with indigenous people's organizations in Latin and Central America, Asia and the Pacific and, possibly, Africa. What we will seek is their view of the most appropriate strategies for preserving traditional knowledge and garnering acknowledgment for their innovations and contributions. Once there is a clear perception of these views, we hope that individuals and organizations will join UNDP and support efforts "to find a framework in which the 'cooperative innovation system and the institutional innovation system' could work together and assume their respective but highly complementary roles."

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LIST OF ABREVIATIONS AND ACRONYMS

ATCC — American Type Culture Collection
CGIAR — Consultative Group on International Agricultural Research
CIAT — Centro Internacional de Agricultura Tropical - International Centre for Tropical Agriculture
CIMMYT — Centro Internacional de Mejoramiento de Maíz y Trigo - International Maize and Wheat Improvement Centre
CIP — Centro Internacional de la Papa - International Potato Centre
FAO — Food and Agriculture Organization of the United Nations
GATT — General Agreement on Tariffs and Trade
IARC — International Agriculture Research Centers
ICARDA — International Center for Agricultural Research in the Dry Areas
ICRISAT — International Crops Research Institute for the Semi-Arid Tropics
IDRC — International Development Research Centre
ILRAD — International Livestock Research and Development Centre
IPR — Intellectual Property Rights
IRRI — International Rice Research Institute
IITA — International Institute for Tropical Agriculture
NAGPRA — Native Graves Protection and Repatriation Act
NCI — National Cancer Institute
NIH — National Institutes of Health
PBR — Plant Breeders' Rights
RAFI — Rural Advancement Foundation International
SCPA — Semi-Conductor Chip Protection Act
TRIPS — Trade-Related Aspects of Intellectual Property Rights
UNCED — United Nations Conference on Environment and Development
UNESCO — United Nations Educational, Scientific and Cultural Organization
UPOV — Union for the Protection of New Varieties of Plants
WIPO — World Intellectual Property Organization

SUMMARY

The majority of the world's people rely on traditional knowledge of plants, animals, insects, microbes, and farming systems for either food or medicines. Eighty percent of the world's population depends on indigenous knowledge to meet their medicinal needs, and at least half rely on indigenous knowledge and crops for food supplies. It is not just poor countries and poor people that benefit from indigenous knowledge of the world's biodiversity. Indigenous knowledge has helped to fuel innovation and development in multi-billion dollar industries, ranging from agriculture and pharmaceuticals to chemicals, paper products, energy, and others.

Too often, those who recognize the value of indigenous knowledge and the "cooperative innovation system" on which it is based make the somewhat romantic argument that it should be preserved for its own sake because it is somehow inherently "good." Yet this knowledge and innovation system is vitally necessary, not to replace the "institutional innovation system" that dominates modern science, but to complement it. The institutional system tends to produce highly specific "micro" improvements that then have broad application in such fields as molecular biology or micro-electronics. The cooperative system, on the other hand, tends to produce macro-system innovations that can only be applied at the local level (for example, because they involve a complex mix of plants, insects, and soil).

What is needed is not a stand-off between two entirely different systems, but a broad approach that allows and respects the contributions of each. Developing such an approach requires better understanding in developed countries of the unique contribution indigenous people and communities make in nurturing and developing the world's biodiversity, and progress on important issues related to protection of intellectual property.

Over 90 percent of the earth's remaining biological diversity is in the tropical and sub-tropical regions of Africa, Asia, and South America. This figure, however, underestimates the true species disparity between developed and developing countries, since far more cataloging of species has been done in Europe and North America than in the developing world.

Yet even before this diversity is fully recorded, species are being lost at an alarming rate. Approximately 100 species per day are becoming extinct. More species are lost per week now than were lost in the preceding *three centuries*. Developed countries have already lost much of their diversity, and the world as a whole is increasingly dependent on the plant, animal, and microbial life of developing countries, where loss and erosion are dramatic as well.

Indigenous communities have nurtured and developed many species within their traditional lands and waters. They possess most of the diversity that still exists in nature, continuing to accumulate knowledge about their uses. Contrary to widespread belief, indigenous knowledge is not the passive, accidental accumulation of information about how the natural environment works. Rather, it is an organized, dynamic system of investigation and discovery that has yielded — and continues to yield — information that could be critical to the survival of the planet. It has made important contributions to agriculture, pharmaceuticals, DNA research, and other industrial production.

The collection of indigenous people's agricultural genetic biodiversity makes an important contribution to the world economy, particularly the economies of industrialized countries. Also, the system of International Agricultural Research Centers (IARCs) that make up the Consultative Group on International Agricultural Research (CGIAR) has, since its inception in 1971, relied on enhancing agricultural biodiversity by using plant genetic resources drawn, directly and indirectly, from the fields of indigenous farming communities in developing countries.

Unfortunately, farmers are seldom compensated for the commercial value of their seed varieties. This situation is made even worse when private companies — invariably in industrial countries — patent material derived wholly or in part from farmer's varieties. Developing-country farmers then find themselves paying for the end-products of their own genius. This approach of adopting germplasm that indigenous farmers have developed and enhanced without developing a research alliance with these innovators and involving them in further development of the varieties is a lost opportunity for the world to benefit from both modern and indigenous knowledge.

Eighty percent of the world's people depend on traditional medicine and medicinal plants for health security. More than two thirds of the world's plant species — at least 35,000 of which have medicinal value — come from developing countries. Conserving this indigenous pharmacopeia is critical to the survival of developing countries in general and indigenous people in particular.

But it is important to developed countries as well. At least 7,000 medical compounds used in Western medicine are derived from plants. The value of developing-country germplasm to the pharmaceutical industry in the early 1990s was estimated to be at least $32,000 million per year. Yet developing countries were paid only a fraction of this amount for the raw materials and knowledge they contribute.

New biotechnologies are increasing the value of traditional plants in a number of ways. First, the line between food and medicine is becoming increasingly blurred as the nutraceutical (food as drugs) sector grows and a growing number of foods are valued for their medicinal properties. Second, advances in micro-electronics now make it possible for companies to screen plants many times more rapidly than before. As a result, "bio-prospecting" has become more profitable; where it used to take months to identify a useful substance, companies using the new technology and receiving advice from indigenous healers can now work much more quickly.

Indigenous people also contribute to world health through fungal and bacterial organisms found in their soils. These microbials contribute to making testosterone, anti-fungal agents, antibiotics, and treatments for acne, manic depression, and gastrointestinal, central nervous, and appetite disorders. To an extent that would astonish Western scientists, indigenous people recognize and value the particular properties of certain soils. Community healers may not know the exact bacteria or fungi, but they know the anti-tumor, antibiotic, and steroid characteristics of the soil they use to treat wounds and diseases. Yet when companies collect this information, developing countries are not compensated for either the material or the knowledge.

DNA research is a whole new area of potential controversy. The Human Genome Diversity Project is an international effort to encode the human gene pool. It includes an effort to collect the DNA of 10,000 to 15,000 indigenous individuals from more than 700 indigenous groups. These "isolates of historic interest" will be studied not only for their historic significance but also for their pharmaceutical properties.

Although patenting human cell lines is currently rare, it is very controversial. Many ethical questions must be answered before human gene research progresses.

A number of trends characterize the current management and use of biodiversity:

Germplasm Storage: Indigenous communities no longer control the genetic material they need for their survival. Even when it comes from developing countries, genetic material is generally stored in developed countries and controlled by developed-country scientists. Nearly 70 percent of all seeds collected in developing countries is stored in industrialized countries or in IARCs; more than 85 percent of microbial collections (yeasts, fungi, bacteria) are stored in developed countries.

Scientific Conservation vs. Survival Conservation: "Scientific" conservation, in which genetic material is held in gene banks and research centers, does not help indigenous communities, which practice "survival" conservation, i.e., taking care of and protecting the species they use, not just for food but for other purposes as well. *Ex situ* germplasm collections are therefore basically extinct to indigenous communities.

Indigenous R&D: Almost all biodiversity in traditional areas has been discovered, developed, and/or protected by indigenous communities. They have a sophisticated understanding of their species and make important contributions as innovators, sometimes taking care of 200 to 300 different species. Particularly important are the many "partner" species that are not specifically cultivated as food crops, but that provide food and income from forests, streams, fallow fields, and home gardens.

New Ownership Pressures: "Intellectual integrity" refers to the accumulated body of knowledge indigenous people have of their biological products and processes. It is to the cooperative innovation system what intellectual property rights are to the institutional innovation system. As industrial countries try to extend their system of intellectual property protection to ever wider fields of innovation — including chemical and pharmaceutical products and processes, microbial, and plant and animal varieties — increasing claims are being made that developed-country corporations are not being paid royalties on the products sold in developing countries. In fact, however, non-payment of royalties is most severe among companies using but not paying for developing-country farmers' varieties and medicinal plants in the development of their products.

Most indigenous communities look on the protection of intellectual property as blasphemous. For all their diversity, the approximately 15,000 culturally distinct ethnic communities share a sense of communal responsibility for their land and its living resources. These resources are meant to be used for the common good of — and protected by — all members of the community.

The institutional innovation system that dominates modern Western science and technology, on the other hand, gives almost limitless rights to individuals and corporations to patent not only innovations and ideas, but increasingly basic research as well. The current system of patent, trademark, design, and copyright laws was created to provide inventors of mechanical inventions (e.g., sewing machines) protection for unique parts and processes. Today, however, a growing number of patent claims are made on activities for which the existing system makes no provision, including computer software; the products, processes, and parts of all life forms; biological end-products; methods of doing business; and mathematical calculations.

These new kinds of patent claims have important implications for the protection of indigenous knowledge and for indigenous people themselves. For example:

- The National Institutes of Health (NIH) and others have attempted to claim patent protection for human genes or DNA fragments related to the human brain simply on the basis that they have found them, without knowing their purpose or potential contribution. If such "driftnet patenting" becomes the norm, anything found in the ecosystem could be patented simply on the basis that everything has some (perhaps still unidentified) utility. Through this approach, large companies can stake claims on large quantities of previously undocumented species.
- A claim by one of the largest chemical companies on genetically engineered cotton, if upheld, could prevent further cotton development by any other enterprise. This could destroy the cotton industry in the nearly 70 cotton-producing developing countries (including 24 of the world's poorest countries). Some 250 million people depend for all or part of their cash income on cotton production or processing.
- In recent years, a growing number of patent claims have been made on biomaterials traditionally used by indigenous communities. After Ethiopian scientists (with the support of a Canadian research institute) conducted research for nearly two decades on the use of endod (African soapberry) to kill zebra mussels, the University of Toledo in the US was granted a patent on the technique based on one day of experimentation. Yet the work proving endod's utility was conducted by Ethiopian scientists examining hundreds of years of innovation and use by Ethiopian communities.

The issue of intellectual property protection is growing for a number of reasons. Genetic interdependence is growing; even the most genetically abundant regions of the world look beyond their own borders for half the germplasm they need for their staple foods, and genetic interdependence is even greater for export commodities. Yet much of this trade could be destabilized by new biotechnologies. The intellectual content of trade is growing as well — and the role of intellectual property in facilitating or hindering trade has been recognized in recent international trade agreements, including the recently concluded round of the General Agreement on Tariffs and Trade, or GATT. Developed countries fear that they are losing their competitive edge to "newly industrialized countries" that have been able to imitate inventions and products and capture markets, and developing countries are under pressure to adopt intellectual property rights legislation.

For all these reasons, indigenous communities need to be prepared to address issues of intellectual property protection. This does not mean that indigenous communities need to accept or comply with intellectual property rights systems they do not welcome or agree with. They should, however, develop strategies that suit their needs and protect their interests. These strategies could involve adopting and evolving existing intellectual property systems, developing new forms of intellectual property protection, or entering into bilateral contractual agreements. However, each of these approaches has drawbacks. What is needed is a new framework combining a number of initiatives and approaches.

A new "intellectual integrity framework" could help indigenous communities protect the intellectual integrity of their ongoing innovations without necessarily complying with or adopting intellectual property rights systems they do not agree with. It should have the following elements:

Intellectual Protection: The intellectual integrity framework should go beyond copyrights, trademarks, and patents to develop new forms of protection for indigenous knowledge of living materials. These could include ***new deposit rules*** for material put into gene banks, an ***ombudsperson*** to investigate complaints by indigenous communities and to review pending patent applications, a ***tribunal*** to resolve disputes, wider use of ***inventors certificates*** to recognize the inventor's contribution without establishing exclusive monopoly control, and other creative new and adapted mechanisms.

Mutual Intellectual Recognition: The institutional innovation system that governs modern science and the cooperative innovation system of indigenous knowledge must become more cognizant and respectful of each other's contributions. Scientists and the public in industrial countries must develop a better understanding of the importance of indigenous knowledge for today's social, scientific, and environmental problems. Indigenous peoples need improved understanding of the value of bio-materials to modern life.

Intellectual Exchange: Most important, indigenous peoples must be actively involved in the development of any new framework. For this reason, an important next step is to prepare materials and meetings to engage representatives from indigenous communities in discussions on how to move toward developing a new intellectual integrity framework that can protect indigenous knowledge.

INTRODUCTION

In 1993, the invocation of indigenous peoples became a kind of mantra at international gatherings. It was the UN-proclaimed International Year of the World's Indigenous People, which had followed in the wake of the Rio Earth Summit. Stories of the "wisdom" of indigenous peoples abound; if the stories expose the depth of knowledge of women — all the better. If they are environmentally sensitive and possess an earthly reality, they are assured a long shelf life.

The sad truth, however, is that indigenous knowledge is still widely dismissed, even in sympathetic circles. The intellectual contribution of indigenous peoples is quietly regarded as suffering from the three "Q"s: indigenous knowledge is either *quaint* (with no currency or modern utility); *quackery* (it never worked or is probably carcinogenic); or *quits* (well on its way to extinction).

That this view is held by the general population in developed countries is dismaying. That it is in large measure shared by scientists and others in the "institutional innovation system" is disastrous. Although it is true that a growing number of scientists are aware that indigenous communities may well harbor useful information about the properties of biological materials that may one day lead to new breakthroughs in medicine or crop production, almost all scientists and science policymakers perceive this collected information as the result of centuries of passive — even accidental — accumulation. Indigenous communities, they assume, have gathered knowledge in about the same way stones gather moss. Rarely does a scientific institution admit to the prospect of a dynamic system of investigation and discovery. This report attempts to document the socio-economic importance of a dynamic "cooperative innovation system" that continues to work — despite overwhelming pressures to destroy it — and continues to offer humankind an irreplaceable hope for planetary survival. Indigenous knowledge has gone unnoticed by the institutional innovation system for so long because it is — not informal or disorganized, as some would claim — but cooperative and conducted within the pace of daily living. In particular, indigenous peoples' knowledge systems operate, often invisibly, within the context of their immediate agro-ecological environment.

The Cooperative Innovation System

Many in the international community believe that the extinction of indigenous knowledge is both inevitable and even desirable. Indigenous knowledge is sometimes regarded as a barrier to the transmittal of new technological tools and information. If indigenous knowledge once had a role, it is said, that role has since been overtaken by others.

This is an extraordinarily dangerous view. Eighty percent of the world's people continue to rely upon indigenous knowledge for their medical needs. At least half, and possibly two thirds, of the world's people could not survive without the foods provided through indigenous knowledge of plants, animals, insects, microbes, and farming systems. To an extent that will astonish most readers, indigenous knowledge continues to be a major source of innovation and development in both agriculture and pharmaceuticals in developed countries, and its role in other forms of industrial production can be expected to increase substantially in the decades ahead.

Indigenous knowledge fuels multi-billion dollar genetics supply industries, ranging from food and pharmaceuticals to chemicals, paper products, energy, and other manufactures.

Integrating Two Systems of Innovation

The cooperative innovation system of indigenous communities can be seen as a mirror image of the institutional innovation system. As a fair simplification, it can be said that the institutional system offers humanity micro-system developments that find application on a macro-scale. Highly specific improvements in molecular biology or micro-electronics may have vast commercial application. The cooperative system, on the other hand, offers broad macro-system innovations that generally can only be applied at the micro-level, i.e., the local environment. Indigenous knowledge often involves the use of complex bio-systems integrating plants, insects, and soil, for example, in a common strategy.

Because of this micro-macro mix, in which each kind of knowledge makes a unique contribution, there is a great need for the continued availability of indigenous knowledge. The more we come to understand the complexity of the eco-system, the more we recognize that the huge global problems that surround us — atmospheric pollution, soil erosion, species loss, malnutrition, and poverty — will not be resolved through UN resolutions or through sweeping new technological "silver bullets."

Both sides of the mirror are needed. The micro-innovations of the institutional system are in no way denigrated by recognition of the contribution of the macro-innovations of indigenous communities. The real challenge for science and technology in the decades ahead is to find mechanisms to allow these two separate, but highly complementary systems, to work together. The challenge for the cooperative system is to recognize the potential merits of the other side. The key to cooperation may rest in the development of a framework that will safeguard the intellectual integrity — but not necessarily the intellectual property — of indigenous innovators. Such a framework must involve organization, public information, certain institutional mechanisms, and the development of a new covenant to guide the relationship of public and private researchers and of cooperative and institutional system innovators.

This Report

This report begins with a survey of recent trends in intellectual property rights (IPRs). The "rules of the game" have shifted in the last few years and the scope of the patent system is becoming limitless. The economic implications of a globalized legal and trade system for IPRs are daunting.

The second section reviews issues and trends in the management and use of biodiversity. The third section emphasizes the economic and social contributions of indigenous rural communities in nurturing biological products and processes; it discusses plants, livestock, microbial, and human genetic materials — the substance of the life industries around which much of the debate over intellectual protection will take place. The final section reviews various policy options available to developing countries and indigenous people: while recognizing the relevance of each option, it argues for the creation of an "intellectual integrity framework"; it also stresses that no policy decisions should be taken without the participation of indigenous peoples' organizations.

I. ISSUES AND TRENDS IN INTELLECTUAL PROPERTY SYSTEMS

The debate over intellectual property protection — in its broadest sense — is probably a good deal older than recorded history. Researchers have sometimes argued that the ritual used by some community healers developed in order to create a "know-how" barrier — allowing the healer exclusive monopoly over the use of medicinal plants and soils[1]. Others have doubted this explanation and suggest that ritual strengthened the psychological capacity of the patient to surmount illness — a factor now widely recognized in industrial medicine.

Did restrictions in access to certain plants, animals, designs, or processes arise from a concern to protect intellectual property or did they come from a need to conserve scarce resources or to allocate social responsibilities within communities? For thousands of years, women in many African cultures have held the right to go into unharvested fields ahead of the men in order to select seed for experimentation and the next planting season. Was this a form of intellectual property or merely a specialist division of labour? In some American cultures, certain clothing designs could only be made — or worn — by certain people. Did this amount to design or trademark protection or was it only a recognition of community roles?

There are approximately 15,000 culturally-distinct ethnic communities in the world today[2] and, while the diversity to be found among these cultures is both marvelous and extraordinary, most indigenous peoples share a sense of communal responsibility for their land and its living resources. It is rare to find a deeply-rooted culture that permits a patent-like monopoly over the products or processes of life. It is largely because of this communal tradition that many indigenous peoples look upon intellectual property — especially related to life forms — as a kind of blasphemy.

The forebearers of today's industrial culture had a similar antipathy. In 480 A.D., Zeno, Roman Emperor of the East, opposed monopolies over fish and textiles, indicating that such monopolies were both common and controversial in the empire. The first formal patent law was recorded in 1474 in the city state of Venice, but the debate surrounding the Statute of Monopolies in England in 1623 shows that society was uncomfortable with the concept of intellectual monopoly. In the nineteenth century, social opposition to patent monopolies rose to the point where laws were rescinded or rights restricted in the United Kingdom, the Netherlands, Switzerland, and Germany. It was only in 1873, at the Patent Congress at the Vienna World's Fair, that international recognition of intellectual property was firmly established[3]. In the 120 years since then, the form and scope of intellectual property has expanded almost beyond recognition. The pace of change in the last two decades, however, has substantively surpassed all developments in this field in the previous century.

The remarkable explosion in science and technology over this same period suggests that there is a correlation between the development of intellectual property systems and the growth of innovation. Even in industrialized societies, however, there is no widespread agreement that this is in fact the case, with some arguing that patents might curtail as much innovation as they create[45]. Some contend that intellectual property rights systems trail innovation; others hold that, whichever comes first, the pace of innovation would slow without intellectual property protection. In general, developing countries have seen IPRs as a barrier to development, restricting the ability of industry to innovate and imitate. Even in the 1970s, so-called industrialized countries such as Canada, Spain, and Ireland questioned the efficiency of the patent system to encourage development and sided with the Group of 77 in calling for major reforms to international conventions[6]. National views on the merits of intellectual property tend to break down along the lines of who is developing new technologies and who needs them. Thus, in the last century, the United States and Switzerland were vociferous opponents of patent proposals that would have forced them to pay royalties for inventions made in other countries. In this century, these two countries are now leading exponents of the same proposals. One of the most outspoken opponents of any form of patent protection was the Geigy chemical company of Basel, Switzerland, that likened the patent monopoly to robbery. Today, Ciba-Geigy, still in Basel, is one of the leading voices in favor of patents in the corporate sector.

The New Trade Environment

The place of intellectual property in society and in commerce has changed significantly in the last half-century. Between 1947 and 1987, the share of US goods in international trade having a high intellectual property content (books, chemicals, and electronics) rose from barely 10 percent to 27 percent of the value of all US exports. Researches estimate that the share of US goods with a high intellectual property content will rise at an annual rate of increase of 2.7 percent to just under 50 percent in the first decade of the twenty-first century[7]. However, taking into account the new importance of micro-electronics/informatics industries, the development of new biotechnologies, and the adoption of international trade agreements, e.g., GATT, NAFTA, that demand global or regional adoption of intellectual property rights over a range of products, the Rural Advancement Foundation International (RAFI) estimates that the share of US traded goods under patent or copyright could leap to 80 percent or higher by 2007 (see Figure I).

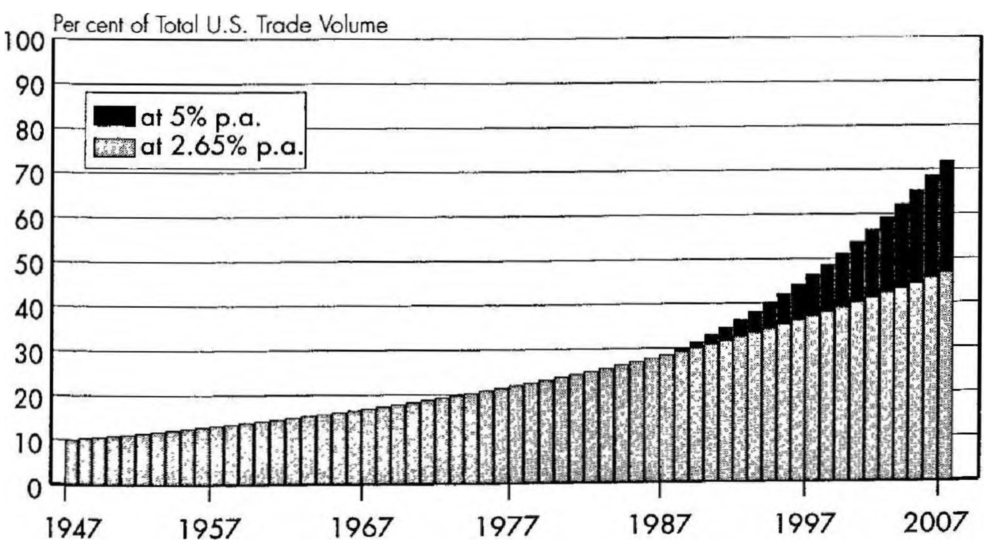
In recent years, intellectual property rights have assumed significant importance in international negotiations. Under pressure from industrialized countries, Trade-Related Aspects of Intellectual Rights Property (TRIPS) were incorporated into the Uruguay Round of GATT on the grounds that the absence of patent protection in some countries could amount to non-tariff barriers. US negotiators maintained during these talks that patent and copyright piracy by developing countries results in a loss to US industry of between $43 billion and $61 billion per annum in sales and royalties[8]. Similar losses are projected for European and Japanese industry.

Such calculations have given intellectual property issues a visibility not seen since the Vienna Congress. When intellectual property rights and technology transfer became an issue at the UN Conference on Environment and Development (UNCED) in 1992, the controversy also incorporated a concern for the protection of indigenous knowledge. *Agenda 21*, the comprehensive plan for national and international action passed at UNCED, in fact, juxtaposes the use of new biotechnologies against international access to biological diversity and indigenous knowledge associated with biomaterial.

The New Corporate Context

Perhaps for the first time, basic or near-basic research is being treated as a marketable commodity. In the arena of new biotechnologies, for example, and in

Figure I: Intellectual property content of US foreign trade as a percentage of total US trade volume from 1947 to 2007. Projections at 2.65% and 5%



Source: GADBOW, R Michael & RICHARDS, Timothy J (eds.), (1988). Intellectual Property Rights – Global Consensus, Global Conflict? Westview Press/Frederick Praeger Publishers, Boulder, CO. USA.

the absence of a traditional product, it is still possible for researchers to buy, sell, and profit from basic research in ways heretofore unheard of. Some biotechnology companies have been able to carry out research for many years, financed by other companies and venture capital, without producing a product and without turning a profit. Shaman Pharmaceuticals, for example, is a bioprospecting company that has yet to produce a product, but it has grown into a profitless company with $120 million in assets[9]. This is possible in part because of IPRs and the ability of companies to patent their research (or to use trade secrecy). IPRs are *vertically integrating* backward into basic research.

Patents are now regarded as bargaining chips or intellectual legal tender that can be traded or bartered. It is possible to envision a Futures Market in intellectual property stocks. The value of a company can increase because of the patent claims it might make or the patent scope it might defend. With so much scientific investigation now moving to biological products and processes, the implications of a genetic stock market in bio-research must be considered. The IPR system now seems to be performing a number of complex market functions that were not originally envisaged. The role and function of IPRs are further complicated by two additional developments — one social and the other scientific.

The Increasing Role of the Private Sector. The obvious social change is the increasing importance of the private sector in R&D; it is proving to be essential for the survival of public sector research. It is debatable whether the amount of money available for public research has increased as a result of private funding, or whether funding from the private sector has simply replaced declining funds from the public purse. At the same time, more public funds are reaching the private sector by direct or indirect transfers.

At least in the United States, the private sector now has a dominant influence over the direction of public research. In 1981, less than six percent of all public sector patents were sold under exclusive license to the private sector. By 1990, the figure had surpassed 40 percent. If present trends continue, by the end of the century close to half of all the intellectual property accruing to US universities and government agencies will be controlled by corporations on an exclusive access basis (see Figure II).

The Homogenization of the Genetics Supply Industry. The scientific change is that it is increasingly possible to apply fundamental research on life forms to a number of diverse commercial activities; these include human pharmaceutical and veterinary medicine, plant and animal breeding, food processing, and a variety of energy and environmental activities. Research developments in transgenics increasingly make it possible for plants to utilize animal and insect genes, for pharmaceutical enterprises to use livestock as manufacturing plants, for medicines and foods to be merged into "nutraceuticals." The result is an emerging "genetics supply" or "life" industry. That this new industrial configuration operates at the centre of life and works with the essentials of human and planetary survival makes its activities all the more important.

The trend toward the privatization of research is only partially driven by the potential for exclusive monopoly patents, and the trend toward the homogenization of life would take place regardless of intellectual property rights developments. Nevertheless, both trends pose new issues and new challenges to the social management of innovation and the transfer of technology.

With the GATT negotiations completed on 15 December 1993 — but still many issues concerning IPR and the Convention on Biological Diversity unanswered — it is realistic to assume that the move to adopt ever-stronger forms of exclusive monopoly in the area of intellectual property, over ever-wider fields of innovation, will continue. It is also likely that most developing countries will, over the next decade, come under strong pressure to adopt IPR legislation from both the World Intellectual Property Organization (WIPO) and possibly the Union for the Protection of New Varieties of Plants (UPOV).

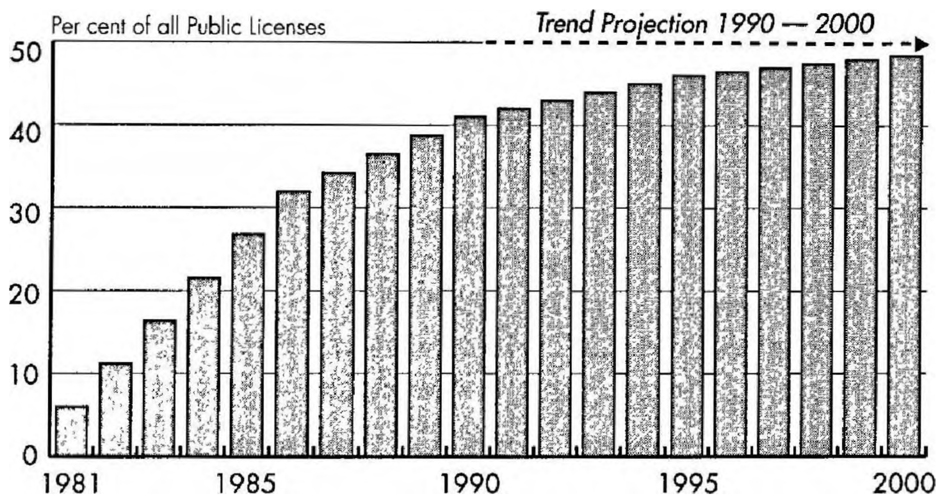
Indigenous communities — regardless of their views on these developments — should develop policies and strategies with this in mind. This is not to suggest that indigenous peoples need accept or comply with IPR systems they do not welcome. Rather, they should be planning strategies suitable for their own needs and conditions.

Recent Patent Applications: Implications for Indigenous Peoples

A number of recent patent applications have caused debate within the scientific and legal communities. The following selected examples have implications for the protection of indigenous knowledge and of indigenous peoples themselves.

The Human DNA Patent Claim. By the middle of 1993, the US National Institutes of Health (NIH) had laid claim to more than 6,000 human genes or DNA fragments related to the human brain. The invention is based on a discovery method that allows NIH scientists to identify material and then undertake a computer search to determine whether or not the material has been previously patented or described. If the material is technically unknown, NIH researchers stake a patent claim on it. The NIH claims portend the diminution or elimina-

Figure II: US public sector licensing: Per cent of all public licenses under exclusive monopoly



Source: RAFI, (1989). Preparing for our Common Future; The Third System and the ETC Equation. Rural Advancement Foundation International. Ottawa, Canada.

tion of the usefulness criteria in intellectual property legislation. Essentially, the NIH has argued that because the genes and DNA fragments they seek to patent are related to the workings of the human brain, they must have utility. By extrapolation to agricultural biodiversity then, a claimant could contend that anything found in an ecosystem (plant, animal, or microbial) must have utility within that system and be a valid subject for protection. While the patent applications were initially turned aside, NIH has reapplied; lawyers who have studied the case believe that the NIH claim will be upheld.

Under pressure from the international scientific community, the new US administration announced, in late 1993, that it would drop its attempts to claim intellectual property over the brain. However, by early 1994, InCyte, a small biotechnology company in California, announced that it was following the NIH lead and had staked a claim of more than 40,000 bits and pieces of genetic material associated with the human brain[10].

Researchers have speculated that, should patent claims such as these made by InCyte ever be accepted in a patent court, international collaboration in efforts to map the genome of various food crops would be severely retarded. What some have characterized as "driftnet patenting" could also directly impact on bio-prospecting since companies might be able to gather up large quantities of undescribed flora and fauna and lay patent claim to them simply on the grounds that no one else has documented the existence of the species.

The Cotton Species Claim. Agracetus (a wholly-owned subsidiary of WR Grace, one of the world's largest chemical companies) holds since October 1992 the equivalent of a "species patent" on genetically-engineered cotton. Agracetus argues that any genetic manipulation of cotton — regardless of the germplasm or method of manipulation — would infringe on its patent. Although conventional cotton breeding is uninhibited, the Agracetus claim, if upheld in the courts, would largely surrender the future of global cotton development to a single enterprise and its licensees. At present the claim is only valid in the United States; but Agracetus could use it to prevent any other country from exporting genetically manipulated cotton to the United States; it may even be possible for Agracetus to prevent the importation of cotton clothing or other finished products containing engineered cotton.

The implications for developing countries would be enormous. Sixty-nine developing countries (32 in Africa, 21 in Asia, and 16 in Latin America) produce cotton, including 24 of the world's poorest countries. Some 250 million adults and children are dependent for all or a part of their cash incomes on cotton production or processing.

The Government of India revoked in February 1994 the Agracetus application for its transgenic cotton in that country. This has sparked the debate in other cotton producing and exporting countries and similar rejections might be expected.

The Soybeans Claim. On March 2, 1994, Agracetus received from the European Patent Office another "species patent," this time on genetically-transformed soybeans. Patents on other major crops — rice, groundnut, maize — are pending. The approved patent amounts to a "species" monopoly on all genetic engineering of soybeans within the European Union for the next 17 years. The patent is also pending in the United States[11 12].

The Endod, Thaumatin, and Neem Claims. Particularly relevant to indigenous peoples are a series of relatively recent patent claims made in the United States on bio-materials traditionally used by indigenous communities in the developing world.

The University of Toledo has been granted a United States patent on the use of endod (African soapberry) to kill zebra mussels. The original research on this technique was conducted by Ethiopian scientists over a 19-year period with support from the International Development Research Centre (IDRC) in Canada. In turn, this scientific research was based upon hundreds of years of innovation and use by Ethiopian communities. The University of Toledo conducted one day of experimentation, then spent four months on legal and scientific work to verify the initial evidence. Opponents to the claim argue that the discovery that endod kills zebra mussels was obvious and that the real work was done by Ethiopians.

Similarly, a patent granted to Lucky Biotech, a Japanese enterprise, with the University of California for thaumatin and the serendipity plant has elicited dismay in West Africa, where the sweet plants are local. That the commercial development of these enormously sweet plants in developed-country bio-factories could further undermine the beleaguered sugarcane industry has increased the concern. Lucky Biotech and the University of California have also sought patent protection in West Africa; if granted, this could enable the patent-holders to prohibit some uses of the plants in countries where they are endemic. Indigenous communities in the region have used and nurtured the plants for many years[13].

WR Grace (which controls Agracetus, the cotton species patent-holder) controls two patents related to the neem tree — the traditional medicinal and pesticidal tree used widely by many indigenous communities in Asia and Africa. No decisions have been made to inhibit continued local use; but some would argue that the qualities of the neem tree are not a new discovery and that — if they were — the intellectual property rights should go to indigenous communities and not to a private enterprise. In September 1993, nongovernmental and peoples' organizations in both India and the United Kingdom organized large protest rallies to oppose neem patents. It is believed that worldwide there exist at least 35 neem patent claims[14]. Ironically, in one Indian language, "neem" means "free."

The Oilseed Quality Claim. In the late 1980s, Lubrizol was granted a patent on the high-lycine characteristic it introduced into sunflowers, arguing that its claim applied to the characteristic for any crop. The claim has been challenged because of the breadth and looseness of the interpretation given by Lubrizol[15].

The Coloured Cotton Claim. Plant breeders' rights have been granted to a US breeder (Sally V Fox) for strains of traditional Andean colored cotton, which she modified through conventional plant breeding to lengthen the staple for commercial weaving. Two textile companies using the cottons advertise that the varieties come from "the ancient peoples of the Americas." Critics maintain that the genius was not in lengthening the staple but in establishing the color. Although the breeder has publicly stated that it was the "ancient peoples of the

Americas" who bred the original cotton species and whose knowledge has been exploited, they will not be compensated for their contribution.

Emerging Issues in Intellectual Property

These and other cases are transforming the legal environment within which IPRs operate. In a sense, the intellectual property system has shown greater flexibility than might have been expected. Nowhere is this more the case than with biological products and processes. Current international precedents and discussions suggest that further changes to IPR law and practice — inconceivable just a few years ago — may now be possible.

As the power and importance of new technologies is recognized, there is increasing uncertainty about the role of intellectual property. Some hold the view that IPRs afford too much power and lend themselves too readily to market manipulation. Others argue that a system that was originally established to provide inventors with protection for sewing machines in the scientific and economic environment of a century ago is not well-suited to meet the needs of either industry or society today.

The problem is particularly acute with respect to IPRs over life forms. Some maintain that the existing IPR system and legal processes will be self-correcting and that, after a period of transition, the system will order itself. Others believe that the breadth and depth of the new technologies and new IPR claims is such that society must become involved and that a new societal dialogue on innovation and protection must emerge. It may be time to reconvene the Vienna Conference of 120 years ago and seek a new social covenant. The issues that should be considered include:

Research Exemption. Traditionally, IPR research exemptions allowed scientists to use patented inventions for non-commercial investigation. With new biotechnologies, so much of the inventive activity involves basic research that some researchers are unwilling to undertake certain kinds of investigation for fear of litigation. The net effect could be a decline in innovative activity.

Scientific Exchange. Other than in the United States (and it, too, is changing), patents may have a tendency to delay disclosure of new research results, since publication prior to patent application nullifies the application. Inventors are thus encouraged to delay releasing research results until they and their lawyers have determined the most advantageous intellectual property strategy and submitted applications. Most observers concede that the pace of innovation is slowed as result.

Product Liability. There is some interest in the notion that a patent holder should be liable for any damages caused by a patent that is proven to perform defectively (for example, a defective process for inserting a gene that results in escapes from cultivated crops to wild relatives of that crop, increasing farm costs and environmental damage). Introducing product liability could lead to greatly constrained patent claims; it could also deter innovation.

Reversal of the Burden of Proof. Some governments and industries are arguing that — in the field of biological products and processes — the onus of proof should be reversed in patent litigation, so that the suspected offender must prove in court that a patent right has not been violated. Although some might find this an alarming reversal of normal judicial practice, it could help indigenous communities that opt to pursue their own patent claims. It could make developed-country enterprises more accountable to indigenous communities for claims related to farmers' folkseeds and medicinal plants.

Criminal Law Enforcement. The expanding importance of intellectual property in commerce has further blurred the boundaries between private physical property and intellectual property. Intellectually, it is difficult to understand why criminal law does not apply to patent or copyright piracy. The implications for innovation could, however, be mixed. In 1990, a bill was introduced in the Philippines that would have placed a form of plant breeders' rights under criminal law; one third of the nationally approved plant varieties developed by farm communities could have been patented by the first person to reach the patent office — and the community could have been jailed for using its traditional varieties. The bill is stalled at second reading in the Philippine Senate[16].

New Rules. The large number and scope of new patent claims has caused concern that the boundaries of patentability may become limitless. Computer software; the products, processes, and parts of all life forms; biological end-products; methods of doing business; mathematical calculations, etc., are either now subject to claims or might become so in the future.

Traditional patent requirements (e.g., an inventive step, non-obviousness, and utility) are being challenged; in the area of Plant Breeders' Rights (PBR) criteria such as distinctness, uniformity, and stability are also being challenged. The old technology criteria no longer seem relevant for the new kinds of technology emerging in informatics and biology; they need to be reviewed and new kinds of protection developed.

Hyper-Intellectual Property Systems. Corporations are increasingly working with combinations of invention protection mechanisms, including not only patents but also trade secrecy and materials transfer agreements. There is an argument for codifying a new level of innovation stimulation/protection that recognizes these combinations or affords different levels of protection for different kinds of technologies. The existing system of patent, trademark, design and copyright laws is too crude for the new technologies. Industry now needs an omnibus, multi-disciplinary system of intellectual property protection.

Protecting Indigenous Knowledge

These issues raise important concerns for the protection of indigenous knowledge, particularly in the areas of non-living cultural products, agriculture, and medicine.

Non-living Cultural Products and Processes. Most of the "liberalization" in intellectual property systems relates either to informatics or biology. Nevertheless, the general trend toward relaxed criteria and wider applications probably makes it more likely both that non-living cultural products and processes (artifacts, etc.) can be protected and that others (non-indigenous persons or enterprises) can establish mechanisms to pirate the work of the cooperative innovation system.

Agriculture. In the field of agriculture, the GATT TRIPS initiative and the 1990 changes to the Convention of the Union for the Protection of New Varieties of Plants (UPOV) concerning the right of farmers to save seed has led one industry official to speculate that 40 percent of US farmers will be contract growers within a few years. Others estimate that farmers will, effectively, become renters of germplasm from the same enterprises to whom they are contracted to sell their end products.

Many indigenous peoples are farmers and have a direct stake in these developments wherever they are in the world. Those who protect and nurture the wild relatives of cultivated crops also have an interest in these trends.

Medicine. The implications for the indigenous knowledge of medicinal plants are less certain. Certainly, the scope of some recent patent claims should make it more possible for traditional herbalists and healers and/or their communities to lay claim to patent protection. At the same time, the NIH's so-called driftnet patent may make it possible for bio-prospectors from the North to gather up large quantities of plants and merely patent them on the speculation that someday someone will discover a use for some part of their collection and be obliged to come to them for license access.

Confronted with this new commercial interest, some governments, nongovernmental organizations, and indigenous peoples themselves are pursuing bilateral contractual arrangements with individual enterprises. However, there are risks in strictly bilateral agreements; these are discussed later in this report.

The recent patent developments and emerging issues have stimulated new and creative thinking regarding the protection of indigenous knowledge. The sweep of claims such as those by Agracetus and the NIH (if sustained) serve to remove most (or all) of the legal barriers to intellectual property over farmers' varieties and medicinal plants and could afford the informal innovation system some extremely broad patent claims of its own (although the removal of legal barriers to the patenting of indigenous knowledge by indigenous people would not necessarily remove economic and political barriers).

There may, however, be a better alternative to simply adopting IPRs for indigenous knowledge. Perhaps what is needed is a pro-active "intellectual integrity system" that establishes mechanisms that could help to safeguard the rights of indigenous peoples and farmers. These mechanisms could include ombudspersons in patent courts; review and reporting procedures; rules for deposit and nomenclature, etc., and could place the financial burden for protecting indigenous knowledge on developed-country industries and governments.

II. ISSUES AND TRENDS IN BIODIVERSITY

Over 90 percent of the earth's remaining biological diversity is in the tropical and subtropical regions of Africa, Asia, and South America. Seven percent of the earth's surface hosts between half and three quarters of the world's biological diversity.

Scientists have tended to assume that what they have discovered is "wild"' now, however, they are recognizing, with some discomfort, that almost everything they find is someone else's toothbrush, shampoo, or vitamin supplement.

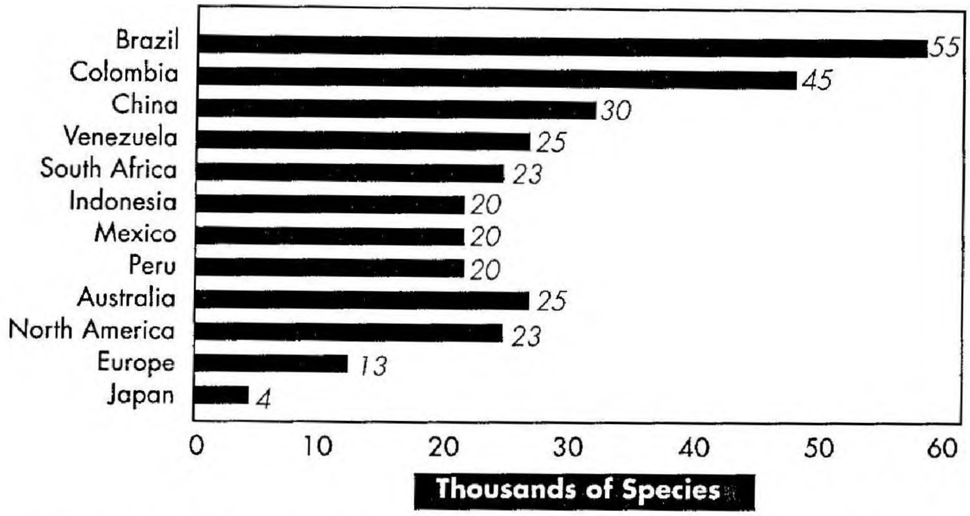
Most Biodiversity Found in Developing Countries

Example after example illustrates how much more biodiversity can be found in developing than in developed countries. There is more biodiversity on a tiny island off the coast of Panama than there is in the entire British Isles. Panama, in fact, is less than one third the size of the United Kingdom, yet it has more than five times as many vertebrate species. Costa Rica is less than a tenth the size of France, but has almost three times more vertebrate species[1]. A single hectare near Kuala Lumpur in Malaysia holds half as many plant species as can be found in all of Denmark[2]. A small volcano near the International Rice Research Institute (IRRI) in the Philippines has more tree species than Canada,[3] and a 15 hectare plot in Borneo has more woody species than all of North America[4]. Figure III shows the vast differences in plant species in selected countries.

The Amazon River has three times more aquatic species than the Mississippi system, and ten times more than can be found in Europe[5]. An estimated 40 percent of freshwater fish in South America have not even been classified. The Indo-West Pacific offers an estimated 1,500 species of fish and at least 6,000 species of mollusc, in contrast to 280 fish and 500 mollusc in the eastern Atlantic. Thailand may have as many as 1,000 species of freshwater fish, and Brazil more than 3,000 — three times more than any other country[6]. Per square kilometer, Mexico and Indonesia both have more than five times the plant diversity of the United States; Peru has seven times the plant diversity of the United States; South Africa, nine, and Colombia, nineteen. The largest plant diversity is believed to exist in Southern Africa.

When it comes to livestock, Asia has 140 breeds of pigs compared to 19 in North America. Similar comparisons can be made for other domesticated ani-

Figure III: Plant biodiversity: Comparisons among selected countries and regions.



Source: DAVID, SD, et al., (1986). Plants in Danger: What do we Know? IUCN, Gland, Switzerland. WRI/IUCN/UNEP, (1993). Guidelines for Action to Save, Study and Use Earth's Biotic Wealth Sustainably and Equitably. Upon citation in: CUNNINGHAM, AB, (1993). Ethics, Ethnobiological Research and Biodiversity. WWF, Geneva, Switzerland. p. 5.

mals — virtually all of which originate in Africa, Asia, or South and Meso-America.

These figures underestimate the true disparity between developing and industrialized countries, since far larger proportions of the total number of species are recorded in developed than in developing countries. By universal consensus, the largest concentration of plant species lies in South America — a region with comparatively few ecologists. In contrast, the largest concentration of ecologists is in North America — a region notable for its lack of botanical diversity[7]. This leads to some understandable statistical distortions. Biodiversity tends to be recorded where Northern ecologists like to picnic, resulting in far more detailed records of species growing along Alpine walking paths and Appalachian trailer parks than of the much more diverse areas of Africa and Asia.

Species Loss/Erosion

Indigenous communities are losing the biodiversity essential to their survival, as approximately 100 species per day are becoming extinct[8]. More species are lost per week now than were lost in total during the preceding three centuries[9]. Nowhere is the loss greater than in industrialized countries. Since the turn of the century, 97 percent of the varieties of 75 vegetable species in the United States have become extinct; 86 percent of apple and 88 percent of pear species have also disappeared[10]. Similar losses have been estimated for pears and apples in Belgium.

Similar losses have occurred for livestock. Half of all of Europe's domesticated animals have become extinct in this century. A third of the remaining livestock species in both Europe and North America are endangered[11].

Losses of medicinal plants in industrialized countries have not been calculated, but are estimated to be significant. Some 150 drugs from North American indigenous communities have been incorporated into the modern US pharmacopeia[12]. The destruction of cultures and agriculture in industrialized countries makes it unlikely that these countries will find many more traditional medicines. In the mid-1980s, industry analysts warned that each medicinal plant lost in the rainforests could lose drug firms sales of more than $200 million[13]. The net effect of species and genetic erosion in developed countries is to leave them almost entirely dependent on the biodiversity of the developing countries, where loss and erosion are also dramatic. In 1990, RAFI estimated that more than 70 percent of the genetic diversity of the world's 20 major food crops had been lost from farmers' fields. Virtually all of those farmers are members of indigenous communities in Africa, Asia, and South and Meso-America.

Current Trends

A number of trends are clearly evident with respect to the management and use of biodiversity.

Germplasm Storage. Indigenous communities no longer control the genetic material they require for their survival. For most of this century, scientists and bio-explorers have argued that biodiversity represents the common heritage of humankind and is the property of no individual or country. Yet biological materials can have enormous economic and social importance. Forty percent of the world's market economy is based directly on biological products and processes; 4.5 percent of the US gross domestic product (some $87,000 million) is based upon "wild" species[14]. For most indigenous peoples — who live on the edges of (or outside) the market economy — biological materials account for 85 to 95 percent of their survival requirements.

Because it is a matter of survival, indigenous people have carefully nurtured and developed diversity. Unfortunately, they have seldom received the benefits from its commercial application. Even when it comes from developing countries, genetic material tends to be stored in, and controlled by, developed-country scientists (see box I).

Box I: Control of Genetic Materials

68% of all crop seed collected in the South is stored in gene banks in industrialized countries or at international Agricultural Research Centres (IARCS).

An even higher share — 85% of all fetal populations of livestock breeds, all originally domesticated in the South — is banked in industrialized countries.

86% of global microbial culture collections (yeasts, fungi, bacteria, etc.) is also held in industrialized countries.

Equity Extinction. "Scientific" conservation does nothing to ensure the kind of "survival" conservation that indigenous communities have practiced for centuries. For all intents and purposes, *ex situ* germplasm collections are extinct to indigenous communities. The seeds, fetal tissue, fungi, and bacteria in gene banks are accessible to market economy breeders but practically inaccessible to survival conservation breeders. In a sense, equity in conservation programmes has become extinct.

Scientists have tended to assume that what they have discovered is "wild"; now, however, they are recognizing, with some discomfort, that almost everything they find is someone else's toothbrush, shampoo, or vitamin supplement. In the past, formal sector researchers only acknowledged *domesticated* and *wild* species; increasingly, they must also recognize an ongoing dynamic relationship with *partner* species, i.e., species that are not specifically cultivated as food crops but that are used, protected and nurtured by farmers and hunter/gatherers but not otherwise domesticated.

The extent of species conservation/ utilization by indigenous people is quite astonishing compared with industrialized-country farmers[15].

Indigenous R&D. Indigenous people make important contributions as innovators. Almost all the biodiversity in traditional areas has been discovered, developed, or at least nurtured and protected by indigenous communities. This diversity forms part of the intellectual integrity of these communities. According to one study, the Chacoba of Bolivia utilize almost four fifths of the woody species in their surrounding forests; the Urubu Kaapor of Brazil use three quarters of their tree diversity; the Panare in Venezuela use about half the documented diversity; and the Tembé of Brazil work with over 60 percent of the woody species around them (see Figure IV). Together, these four communities use between a fifth and a half of all woody species for food and up to a third for medicinal purposes[16].

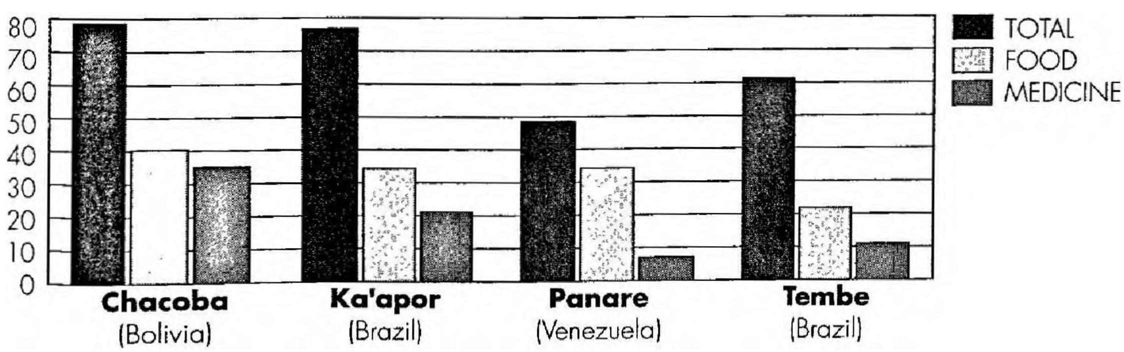
Even the most avid gardeners in Europe and North America rarely deal with more than 20 plant species. The Huastic of Mexico have been known to nurture as many as 338 different species. Ribereños in Peru routinely protect 168 species. In Africa, the Suazi of Swaziland nurture/use about 200 species, and the Tembe of Southern Africa commonly use 106 species[17].

The importance of "partner" species to the food supply of indigenous communities is illustrated by the example of the Mende of Sierra Leone, who draw less than a fifth of their nutrition from cultivated species and more than half from forests, streams, and fallow fields. The remainder comes from local markets and plantation crops[18]. In the Bungoma District of western Kenya, almost half of all families incorporate partner species in their home gardens and only a marginally lower percentage of families collect partner species for food in the forests[19].

Not surprisingly, women tend to make better use of partner species than men. In Kenya, during the rainy season, women draw 35 percent of their plant material (for food, medicine, and fibre) from so-called "wild" plants[20]. Partner species are also important to the incomes of local communities, especially women. Poor and middle-class women in Uttar Pradesh, India, derive one third to almost half their income from forest species and plants found in common resource areas, while men in the region obtain barely 13 percent of their income from this source[21].

Among transmigrant communities in Indonesia, almost two thirds of food production, four fifths of consumption, and nearly half of all income is drawn not from rice fields, but from home gardens, underscoring the importance of

Figure IV: Informal innovation and biodiversity: Indigenous peoples' use of total rainforest woody species



Source: PRANCE, GT, (1989). Economic prospects for tropical rainforest ethnobotany. In: BROWDER, JO (ed.), (1989). Fragile Lands of Latin America: Strategies for Sustainable Development. Westview Press, Boulder, Colorado, USA. pp. 61-74.

partner species and minor cultivated crops even in regions known for their dependence on rice[22].

The nutritional importance, like the economic importance, of partner species has generally been underestimated. A groundbreaking study in 1979 demonstrated that the !Kung community in Southern Africa has a higher per capita calorie intake than the average for either Africa or Asia, largely as a result of hunting and gathering 84 plant and 54 animal species over a work week[23].

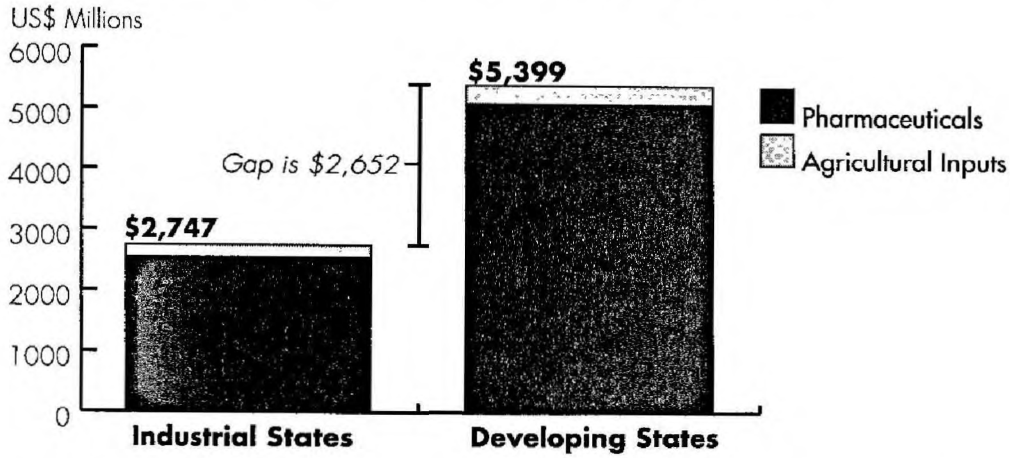
New Ownership Pressures. Intellectual integrity is to the cooperative innovation system of indigenous communities what intellectual property rights are to the institutional innovation system. For most of this century, but especially over the past three decades, industrialized countries have been extending their intellectual property system to cover most fields of innovation, including chemical and pharmaceutical products and processes, microbials, and plant and animal varieties. In the United States — and very likely soon in Europe and Japan — virtually all biological products, processes, and parts thereof, can be subject to exclusive patent protection.

This trend is especially poignant for indigenous peoples in the context of the GATT TRIPS negotiations. Following a detailed survey of seven large developing countries, a 1990 study of US negotiating options concluded that US corporations were losing more than $135 million a year in royalty payments on pirated agricultural chemicals, and $1,684 million in royalties on pirated pharmaceuticals[24]. By extrapolating these estimates to include all developing countries, RAFI estimates that US agricultural chemical royalty losses (in the terms adopted by the US researchers) are approximately $202 million, and pharmaceutical losses approximately $2,545 million.

Reverse Piracy. However, if the real contribution of the cooperative innovation system is calculated, the pirate roles could be reversed. RAFI has juxtaposed the theoretical losses in royalties/sales for crop chemicals against theoretical royalty losses for farmers' folkseed varieties; it has assumed the study's royalty rate of 2 percent for crop chemicals on global seed industry sales of $15,100 million. Although this would provide an unconscionably low royalty for farmers' varieties, it would still amount to $302 million — or $100 million more than the "pirated" royalties for chemicals.

Similarly, if royalty payments were paid to developing countries on the one quarter of pharmaceutical sales based on products derived from medicinal plants, the royalties due to the South would amount to approximately $5,097 million[25]. This assumes the study's royalty rate of 20 percent for pharmaceuticals.

Figure V: Reverse IPR-related payments: Pharmaceuticals and agricultural input originating from developed and developing countries



Source: GADBOW, R Michael & RICHARDS, Timothy J (eds.), (1988). Intellectual Property Rights - Global Consensus, Global Conflict? Westview Press/Frederick Praeger Publishers, Boulder, CO. USA.

In other words, in these two biological industry sectors, industrialized countries would be net losers to developing countries, in the range of $2,700 million per annum[26] (see figure V).

Developing Trends. Some trends in the area of IPRs are still developing. NIH and British Medical Council claims on several thousand genes and DNA fragments related to the human brain have significant implications for biological diversity. Everything in farmers' fields or in the rainforest could become patentable material, with patent aspirants needing only a visa in order to lay claim to vast quantities of plants and animals bred and nurtured by indigenous or other rural communities. The *Wall Street Journal* reported that the NIH action was leading to a breakdown in the Human Genome Project, and that breeders had observed parallel problems in scientific exchange in rice and maize[27]. *The Economist* likened the claims to patenting by trawler[28]. Theoretically, the remarkable flexibility shown in the US patent system opens up wide opportunities for indigenous peoples to stake their own substantial monopoly claims. Assuming access to legal support, indigenous communities could claim most (or all) of the biodiversity within their traditional lands. In fact, this is not likely to happen.

III. INDIGENOUS KNOWLEDGE OF BIODIVERSITY

Indigenous and rural communities possess the substantial majority of agricultural and medical biodiversity that continues to exist *in situ*. Indigenous people have nurtured and/or developed much of the material within their traditional lands and waters. Knowledge of the use of plants, animals, and microbials has been acquired, and is continuing to accumulate wherever indigenous peoples are free to determine their own destinies.

Agricultural Biodiversity

In considering the flow of benefits to and from indigenous peoples in the area of agriculture, it is useful to look at the role and function of the various International Agricultural Research Centers (IARCs) that comprise the Consultative Group on International Agricultural Research (CGIAR). Since its inception in 1971, CGIAR has performed a remarkable agricultural research and training function in developing countries. Its global effort to increase agricultural productivity has relied on enhancing agricultural biodiversity by using plant genetic resources drawn, directly or indirectly, from the fields of indigenous farming communities in developing countries.

The sometimes random, sometimes systematic collection of indigenous peoples' agricultural genetic diversity has yielded considerable economic benefit to the world community, including industrialized countries. Genes from the fields of developing countries for only 15 major crops contribute more than $50,000 million in annual sales in the United States alone[1]. RAFI estimates that the contribution of IARC-held germplasm to developed-country crop production is at least $5,000 million per annum; almost all of this germplasm has been collected in developing countries.

It is, of course, difficult to quantify the intellectual contribution of farmers and indigenous communities to industrialized countries. Most gene bank directors acknowledge that the contribution of farmers' varieties is considerable. A great deal of the most commercially usable material flowing northward passes through IARCs either directly from their gene banks or as improved material for field trials. RAFI has attempted to estimate the value of farmers' varieties. These are crude estimates, but they give an indication of the enormous contribution of developing-country germplasm to both the food consumption and the agricultural earnings of developed countries. Four crops are discussed; in addition, germplasm from potato, chickpea, barley, livestock breeds and many other materials make significant contributions to industrial-country agriculture.

Wheat. RAFI estimates that germplasm obtained through the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico contributes

$2,700 million in crop production in industrialized countries. This calculation is based on figures from three research studies which estimate the value of developing-countries' contribution to the wheat germplasm of four industrialized countries (the United States, Italy, Australia, and New Zealand)[2]. Together, these four countries account for 16 percent of average annual wheat production. Extrapolating the same ratio of benefits to all industrial countries produces the $2,700 million per annum estimate. This would represent a 100-fold return on the northern donors' annual investment in CIMMYT.

Rice. RAFI estimates the value of the International Rice Research Institute's (IRRI's) contribution to the rice production of developed countries to be about $655 million per year. This represents a 22-fold return on Northern countries' investment. This figure is derived by extrapolating from US Agency for International Development figures on the production of US semi-dwarf rice crop which was developed on the basis of IRRI material.

Maize. Currently only a small proportion of developed-country maize is based on tropical germplasm (about 0.1 percent of the value of the US crop, which in turn is about 68 percent of all maize production in industrialized countries). But it appears that US companies are increasing their use of tropical maize material. CIMMYT is also considering returning to the development of hybrid maize varieties. This segment of CIMMYT's work might be privatized in order to more effectively work with small entrepreneurial seed merchants in the South and with high-tech biotech enterprises in industrialized countries. The impact of such a move on indigenous farming communities is uncertain, but there would be cause for concern that the poorest farmers might not have the resources to access hybrid maize lines on a regular basis and that an important public sector source of innovation might close.

Beans. RAFI estimates that industrial countries benefit by about $111 million from material provided by the International Centre for Tropical Agriculture (CIAT) — a fourfold return on investment.

Mutual Benefit

Both International Agricultural Research Centers and indigenous farmers can take pride in their contribution to global agriculture. The problem is not that industrial countries benefit from these centers, but that the commercial value of developing-country seed varieties and germplasm is not acknowledged and compensated for. The situation is made even worse when industrialized countries patent material wholly or partially derived from farmers' varieties. As private companies move into the developing countries' seed markets, indigenous farmers are finding themselves paying for the end product of their own genius.

The most egregious example of this occurred in the late 1980s, when the British-based Agricultural Genetics Company applied for a patent on the Cowpea-Trypsin Inhibitor (cpTI) gene extracted from a cowpea variety obtained from the International Institute for Tropical Agriculture (IITA) in Nigeria. The initial institutional discovery and work had been done at IITA but the patent was applied for by the UK concern. The specific gene — estimated to have a sales value of hundreds of millions of dollars — was subsequently licensed to a number of private breeding and biotech companies.

West African governments felt that ownership of the discovery rested with African governments or farmers. In fact, the specific genetic material used seems to have come from a US gene bank to IITA, although it is assumed that the US material originated in Africa. While indigenous farmers in Africa might not have been aware of the specific cpTI gene, they were aware of the utility of the plant in inhibiting insect pests.

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Developing countries, of course, benefit as well from the system of international agricultural research centers. Thirty-seven million hectares are sown to CIMMYT wheat varieties in developing countries; this represents 54 percent of all wheat grown in those countries and gives farmers more than $17,000 million annually. Even CIMMYT maize, comprising only 8 percent of developing-country maize production, contributes about $1,600 million per year to their farmers. Nearly 70 percent of developing-country rice crops are from IRRI and CIAT varieties. According to CGIAR, the annual value to developing countries of growing these varieties is in the range of $50,000 million. This would imply that virtually 99 percent of the wealth created by the CGIAR system of germplasm conservation and enhancement accrues directly to developing country farmers and their communities.

This is, of course, an oversimplification. If 70 percent of Asia's paddy lands were not in IRRI varieties, they would be in farmers' or national varieties. Farmers' varieties, while not always as high-yielding, tend to have a much higher market value than the less tasteful IRRI strains. Moreover, IRRI varieties have stimulated a $2,400 million agro-chemical market solely for rice fields — a major benefit to industrialized countries. Even IRRI agrees that it has consistently overestimated the need for chemicals on rice and that these chemicals have caused severe human health hazards and contributed to significant environmental pollution in Asia. This has had important costs for farmers. In some countries, certainly the Philippines, IRRI's presence has led to the stifling of national research planning and activity.

The major winners from the system have been the international enterprises seeking control and ownership over biological products and processes. All the monetary benefit flowing to developed countries appears directly in their cash economies. The financial gains for developing countries are only estimates, since only a small percentage of the crops involved ever appear in the marketplace. Thus for corporations, the gain is relatively clear and direct. For indigenous farmers, there is an uncalculated opportunity cost.

Lost Opportunity

Whatever the distribution of benefits between developed and developing countries, the world lost an opportunity for a collaborative research framework between the cooperative innovation system and the institutional innovation system that could have been beneficial to all parties. This opportunity was lost when CGIAR and the agricultural research institutes adopted the "end products" of indigenous innovation — farmers' already-enhanced germplasm — without adopting a research alliance with the original innovators and their process of innovation.

Pharmaceutical Biodiversity

Eighty percent of the world's population is dependent on traditional medicine and medicinal plants for their health security[3]. The conservation of pharmaceutical biodiversity, like the conservation of agricultural biodiversity, is critical to the survival of developing countries in general and indigenous peoples in particular.

The situation in the pharmaceutical industry is similar to the agricultural industry. More than two thirds of the world's plant species — at least 35,000 of which are estimated to have medicinal value — come from developing countries. At least 7,000 medical compounds in the Western pharmacopeia are derived from plants. According to an intergovernmental meeting of developing-country experts in Tanzania in 1990, the estimated annual value of developing-country germplasm to the pharmaceutical industry could be as high as $47,000 million by the year 2000[4 5].

This is a modest estimate. Roughly one quarter of pharmaceutical sales in the United States are of drugs derived directly or indirectly from plants. At the beginning of the 1990s, worldwide sales of all pharmaceuticals amounted to more than $130,000 million annually; a conservative estimate would be that $32,000 million of these sales are based upon traditional medicines. Yet, developing-country exports of medicinal materials to developed countries, when surveyed a decade ago, were only $551 million[6]. In other words: $32,000 million in worldwide sales yielded developing countries only $551 million in revenues, despite the fact that these countries provided the raw materials and a substantial part of the knowledge.

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New Markets

New biotechnologies are blurring the line between food and medicine. Already, the "nutraceutical" (food-as-drugs) sector in the United States is worth over $27,000 million and is growing quickly. In Europe and Japan, herb-based drug products account for 11 percent and 10 percent, respectively, of the over-the-counter drug market. If all pharmaceutical products with natural ingredients were included, they would account for a third of the total European market — valued at not less than $3,000 million by the year 2000. In Germany alone, over 280 of the 450 known medicinal plants have been evaluated and are being adapted for commercial use[7].

Recent decisions by the US National Cancer Institute (NCI) give an indication of the importance now placed on medicinal plants. In 1980, NCI suspended a 20-year program to collect medicinal plants; in 1986, it renewed and enlarged the program when the opportunities created by new biotechnologies became evident. Between then and the end of 1992, the NCI paid for the collection of 23,000 plant samples of 7,000 species, almost all of which came from the South.

Advances in biotechnology have been facilitated by advances in micro-electronics that make it possible to screen samples at a faster rate. Through random sampling, only one molecule in about 10,000 samples has any hope of commercialization. In the past, it could take many months or years to find a single useful substance; today it is possible for a modern pharmaceutical lab to survey

150,000 samples a year[8]. As a result, by the late 1980s, 200 companies worldwide were reported to be actively screening plants for pharmaceutical compounds[9].

By consulting indigenous peoples, specialist bio-prospectors can increase their success ratio from one out of 10,000 samples to one out of two. If three different communities are found to use the same kind of plant for medicinal purposes, Shaman Pharmaceuticals, for example, collects the plant for careful study. In some instances, healers have identified specific plant remedies for the company simply on the basis of a photograph of the symptoms of a specific human disease[10].

Of the 120 medically useful active compounds presently derived from plants, close to 90 plants serve a similar purpose in the pharmaceutical industry as they did when used by indigenous peoples[11]. The root of the serpent-wood species *rauvolfia serpentina*, widely used for centuries in India for a number of maladies including hypertension, is a classic example of the commercialization of indigenous knowledge. By 1967, almost 90 percent of the anti-hypertensive drug market in the United States was based on these roots, and the tree continues to be the basis of several other important medicines[12]. US researchers have recently concluded that if they had taken advantage of indigenous advice when collecting plants in the 1950s and 1960s, their success rate could have doubled[13].

Indigenous Knowledge and Soils

The contribution of indigenous peoples to world health comes not only through medicines derived from plants and animals, but also through the soil. At least 12 percent of the fungus accessions, and almost 4 percent of the bacteria accessions, in the American Type Culture Collection (ATCC) are derived from developing countries, mostly from soil samples.

It is likely that the extent of the contribution of indigenous peoples to soil sampling (including fungus and bacteria from soils and other sources) is seriously underestimated, since the ATCC does not consistently record collection sites or patent data. A particularly significant omission was noted in 1990 when the University of Florida patented a Brazilian fungus known to be lethal to fire ants that can cause over a billion dollars in damage to US crops. Neither the patent application nor the ATCC registration reported that the fungus was given to Florida researchers by Brazilians. Only anecdotal accounts in biotechnology industry journals made the connection[14]. Brazilian farmers apparently were aware that "something" in the soil kills fire ants.

Both ecologically and economically, indigenous communities should be aware of the enormous contribution of micro-organisms to everything from food processing and biocides to human health care and finishing waxes. These micro-organisms, largely found in soils, can have staggering monetary value and their removal creates the kind of socioeconomic loss that indigenous societies have come to know for plant genetic erosion. Major companies are actively working to collect this material:

- Merck, the world's largest pharmaceutical company, for example, has patented material gathered in at least nine countries. This material is useful for making testosterone, an anti-fungal agent, and antibiotics, and for developing treatments for acne, manic depression, and gastrointestinal, central nervous, and appetite disorders.
- Pfizer has collected fungi and bacteria in at least 15 countries, with more than 30 ATCC samples resulting in patent claims.
- Bristol-Myers has 38 foreign accessions deposited with the ATCC, all with at least one patent claim. In all, 15 countries have made soil bacteria and fungi available to the company.

India and Brazil have been popular collection sites. Just five companies (Bristol-Myers, Pfizer, Groupe Lepetit, Lederle Labs, and Merck) have registered a total of 35 bacterial accessions from India with patent claims. The ATCC records 258 accessions from Brazil.

Two points are worth emphasizing about all of this activity. First, this is an issue of national sovereignty. Governments must determine policy for land and resources. The removal of resources from national territory is a violation of the rights of people through their governments. No country with a valuable raw material has ever been known to give it away. The United States did not surrender Texas oil to the British merely because British petroleum technology was superior. Canada did not give away its uranium, Russia its coal, or Norway its timber — although each used outside technology and assistance to develop its industry.

Second, to a degree that would be astonishing to many scientists, the particular properties of certain soils have long been recognized and valued by indigenous peoples. They may not be aware of the exact bacteria or fungi resident in the soils, but the anti-tumor, antibiotic or steroid characteristics of certain soils are known and valued. Community healers customarily apply soil to wounds and diseases. Competent bio-pirates make use of this community knowledge when they go off "inventing."

Developed countries need the material and the knowledge of indigenous people. Every year, the US National Cancer Institute sifts through more than a tonne of soil material (more than a thousand individual samples) seeking valuable germplasm. According to microbe-hunters at the University of California at San Diego, the drug industry spends billions of dollars annually screening soil organisms[15].

Indigenous Human Germplasm

Developed-country researchers have regarded indigenous people as research objects for more than half a century. With scientists beginning to explore genetic diversity through DNA analysis, this interest is increasing, as is the controversy surrounding it.

In the 1920s and 1930s, a medical researcher opened the graves and removed the bodies of 756 Alutiiq people of Larsen Bay, Alaska; some of the graves were only ten years old. The researcher shipped the remains to the Smithsonian in Washington, DC, where they were stored with almost 18,000 other indigenous cadavers owned by the museum. Some threatened human communities have more dead members in museums than live members in their traditional territories.

A 1986 Louisiana court decision (Charrier vs. Bell) changed researchers' views on the legality and morality of acquiring indigenous human remains. The Tunica-Biloxi community won back the graves of several indigenous members even though the land was not titled to them. Partly as a result of the law suit, the US Government enacted the Native Graves Protection and Repatriation Act (NAGPRA). Based on this act, the Alutiiq successfully demanded the return and reburial of their ancestors in 1991.

Many other aboriginal communities are forcing museums to surrender their cadavers and, at the museums' expense, return the bodies for traditional burial. Most notable in these efforts is the global struggle waged by the *Hui Malama i na Kupuna o Hawai'i'i Nei* (Group Caring for the Ancestors of Hawai'i), organized in 1989 to block the destruction of 1,100 graves on the island of Maui. After they succeeded in preventing construction of a hotel on the grave site, they campaigned successfully to recover human remains from 18 museums in the United States, Australia, Canada, and Switzerland[16].

These precedents could prove important as DNA research progresses. As a result of the US law, other countries are considering similar legislation.

The Human Diversity Collection

Although human cell line patenting is still relatively rare, it takes on particular relevance. First, because of the newly agreed GATT TRIPS accords which require signatories to introduce legislation which ensures patenting of micro-organisms and hence human cell lines. Second, upon ratification of the Biodiversity Convention, existing collections will become the property of the depositors.

Affiliated with the Human Genome Project and supported by the US National Institutes of Health and other agencies and governments, the Human Genome Diversity Project has been established to collect and "immortalize" the DNA of between 10,000 and 15,000 indigenous individuals from approximately 722 different peoples. Identified by the Project as "Isolates of Historic Interest (IHIs)," the samples will be collected and stored in the American Type Culture Collection, where they will be studied for not only their historic significance but also their pharmaceutical properties.

The commercial value of such human material is underscored by a number of recent developments. In early 1993, unique genetic material found in the isolated community of Limone, Italy, was shown to bear a gene that codes against many cardiovascular ailments; Swedish, Swiss, and US firms are reported to be seeking patents on the human material. Also in 1993, NIH offered contract funds to private biotechnology enterprises to obtain DNA samples from weakened AIDS victims both to test potential vaccines and to derive materials that might form components of future vaccines. It was recently disclosed that a tumorous spleen patented and licensed to Sandoz has a potential market value of $1,000 million. In mid-1993, IDRC researchers in Nairobi, Kenya, reported that a unique group of 24 prostitutes in that city — from among a survey group of 1,700 — appear to be resistant to the AIDS virus. Other IDRC researchers found that a Sudanese community is resistant to malaria.

According to a RAFI survey of the American Type Culture Collection, at least a third of the human cell lines stored there are under some form of patent claims[17]. In doing this survey, RAFI learned that the US Secretary of Commerce had filed US and world patent claims on the cell line of an indigenous woman from Panama. Although the claim was dropped in November 1993, after protests from the World Council of Indigenous Peoples and the Guaymi General Congress, it is not yet clear whether the human cell line will be repatriated to the Guaymi General Congress. Partly in response to the Human Genome Diversity Project and to the patent claim on the Guaymi cell line, the Indigenous Peoples Biodiversity Network was formed with the objective of defending the interests of indigenous peoples regarding access to, and use of biodiversity and their knowledge about it.

Although 79 institutions have been active in intellectual property related to human-cell-line material, 10 institutions account for more than half of the patent claims for which depositor information is recorded by the ATCC. In general, the explicit patenting of human cell lines continues to be rare.

The Human Genome Diversity Project has established an Ethics Committee to review intellectual property and "prior informed consent" issues raised by the project. US Government and other officials have advised the committee informally that the collection and removal of human cell lines from other countries might have to be dealt with under the Biological Diversity Convention.

Industrial Biodiversity

After several decades of declining market share, plant material is rebounding and replacing industrial chemicals in some industrial sectors. Rapid progress in biotechnology and concerns about pollution, along with declining costs for living natural raw materials, have combined to stimulate new commercial interest. In 12 of 14 commodity groups studied in 1992, plant-derived materials had dropped in cost by as much as 30 percent since the mid-1980s. In the two remaining fields (detergents and plastics), the costs of plant materials were expected to drop by about 50 percent by the mid-1990s[18]. Plant materials are not only abundant and more environmentally friendly than most industrial chemicals, they are also becoming price competitive.

With the application of new bioprocessing technologies to plant matter, some analysts are projecting that a third of all industrial materials could soon be derived from plants. In 1990, the US market for the industrial use of plants was about 6.5 million metric tons, or barely two percent of the total industrial materials market (excluding paper)[19]. If the catchword on Wall Street in the 1960s was "plastics" and "synthetics," the rallying cry today is "plants" and "natural." Individual plants collected from Peru to Ethiopia give developed-country manufacturers and food processors enormous value at almost no cost.

This trend presents both opportunities and risks for indigenous communities. On the one hand, industry's new interest in natural oils, adhesives, latexes, etc., as well as in finding new sources of pulp and paper, offers new opportunity. On the other hand, it greatly accelerates the rate at which outsiders are seeking to put claims on indigenous resources.

Conclusion

Indigenous communities pursue a cooperative innovation system that observes the same fundamental processes of discovery and experimentation that characterize institutional innovation systems. Innovation in the cooperative system is incremental and evolutionary, but with respect to plant and livestock breeding, the institutional system is as well.

The institutional innovation system's form of intellectual property protection is expanding and evolving in ways that may make it reasonable to incorporate the innovations of indigenous peoples. It is demonstrating a previously unheard of flexibility with respect to biological products and processes. However, even though such expansion may be technically feasible, it may not be politically realistic or even desirable. The next chapter examines the major policy alternatives available to indigenous communities.

IV. ALTERNATIVES TO INTELLECTUAL PROPERTY RIGHTS

The Convention on Biological Diversity adopted in Rio de Janeiro in June 1992 at the UN Conference on the Environment and Development encourages countries to pursue bilateral contractual agreements by withholding their *ex situ* (gene bank) collections and/or by bartering access to *in situ* materials still in their fields, forests, and estuaries. Yet genetic material today is an international commodity, and interdependence is growing constantly.

Genetic Interdependence

Two thirds of gene bank collections are held, or controlled by, developed countries, as is over four fifths of livestock and microbial material. Such already stored material is of most immediate commercial use. By and large, companies will only look to the fields and forests after they have rummaged through the gene banks and cell libraries.

Genetic interdependence characterizes both food crops and export crops. Even the most genetically abundant regions of the world look beyond their own borders for half the germplasm they need for their staple foods. Wheat, for example, originated in the Near East, but the specific genes that inspired semi-dwarf wheats and propelled the Green Revolution came from Japan via Mexico, and disease-resistant genes found recently in Brazil may support crop yields as far away as India. Tomatoes originated in Latin America, but some of their most useful processing qualities have come from the Philippines; and when corn blight struck the southern United States, resistant genes were found as far away as West Africa even though the crop's genetic "home" lies in Meso-America.

Global genetic interdependence is particularly pronounced among export commodities. Although Brazil is the world's primary source of natural rubber, most rubber is produced in Southeast Asia. Biotech companies are presently evaluating other latex-bearing plants with origins as scattered as India and Mexico. Southeast Asia is also the region where most oil palm is produced, although the crop's center of genetic diversity is in Africa. Similarly, the center of banana production is in South and Central America, although the genetic "home" of bananas and plantains is in Southeast Asia. Latin American coffee originated in Ethiopia, and East Africa's sisal production is based upon germplasm from Central America.

Colonial history has been a botanical chess game — a history of transferred production. The old centers of diversity are seldom the new centers of production — or of technology for that production. Tea may have originated in China, but some of the most commercially viable material might well be found in Sri

Lanka or East Africa. Cocoa is a South American plant, but its four centuries of traditional production in West Africa could mean that invaluable traits could be found a continent away. Then again, some biotech research on cocoa indicates that the crop could be supplanted by genetically manipulated oil palm. Similarly, biotechnology could further subvert sugarcane production in the Caribbean and elsewhere with thaumatin production in West Africa. Many spices that originated in Southeast Asia are now grown in the Indian Ocean area and in Africa, and may soon be brewed "naturally" in San Francisco processing plants.

A conservative estimate is that $80,000 million in annual developing-country exports are based upon germplasm that originated in another distant part of the South. Also conservatively, RAFI estimates that at least $20,000 million of this production (25 percent of the South's leading exports) could be de-stabilized by new adventures in biotechnology.

Intellectual Property Protection for Indigenous Peoples

For at least three reasons, the importance of intellectual property is likely to grow substantially in the years to come. First, the intellectual content of international trade is increasing significantly. Second, the United States and some other industrialized countries fear they are losing their competitive edge in international trade, at least partly because of the ease with which "newly industrialized countries" have been able to imitate foreign inventions and capture markets away from the countries of innovation. Third, international trade agreements, including the recently concluded GATT accord, have evolved to recognize the importance of services, investment and intellectual property as either facilitators or barriers to trade.

In this context, indigenous communities are faced with a number of possible policy strategies. Whichever strategy they adopt, however, indigenous communities should not move toward environmental entrepreneurism but toward collective self-reliance. Bargaining between developing countries and indigenous peoples on the one hand and developed countries and private industry on the other hand should be undertaken within the framework of intergovernmental arrangements and on a collective basis.

The major strategies available to indigenous communities include adopting existing (and evolving) intellectual property systems; developing a *sui generis* system of intellectual property protection; entering bilateral contractual arrangements; or creating a new system combining various elements of each of these. These strategies, and the opportunities they offer, are reviewed below.

The Current System of Intellectual Property Protection

Although most countries have their own national legislation on intellectual property protection, this legislation is in the majority of cases based on and governed by international conventions administered by the World Intellectual Property Organization (WIPO).

For indigenous people's organizations, the existing system offers a number of opportunities, in particular the conventions on copyrights, trademarks, and patents.

Copy Rights

The intent of international copyright law is to protect artistic works from being copied without the express permission of the author. Only the "form" of the art is protected, the "ideas" contained in the work are freely available to all. Copyright law assumes that there is one author, and protection is normally provided for a period of fifty years beyond the life of the author.

The rapid growth in the volume and value of the computer program industry in recent years has changed the legal concept of copyright considerably[1]. Even with these changes, the industry has not been comfortable with copyright law and there is a movement in several countries to establish an international convention specific to computer software. For indigenous people, the copyright system is even less satisfactory. Whether the material to be protected is living or inanimate, the "author" is rarely an individual but a community. The period of protection should continue as long as the community survives, implying a kind of "perpetual" protection that would be inappropriate to copyright. Further, in the case of biological or living inventions, it is also the "idea" that indigenous communities would wish to protect.

Precedents exist for developing significant variations of copyright protection. The US semi-conductor industry felt that copyright protection — with its loose definition for originality — was ineffective to protect the layout-designs of integrated circuits. In 1984, the US Congress adopted the Semi-Conductor Chip Protection Act (SCPA), which differs from normal copyright protection in that the requirements of novelty and the demands of reciprocity are more stringent, and in the duration of the protection, which is only ten years as opposed to normal copyrights which usually have a duration of 50 years beyond the life of the author. Variations of this law were subsequently adopted in 19 other countries, including Japan and the 12 member countries of the EU.

Trademarks

Trademark law is generally more restrictive in its interpretation than copyright law. It is possible to retain a trademark in perpetuity as long as it is in use and fees are paid. Yet trademarks also do not meet the needs of indigenous peoples to protect works that have already been widely copied. Nor do they protect indigenous knowledge related to biological products or processes — arguably the major area where communities are likely to derive financial benefit.

However, a trademark affirming the authenticity of indigenous peoples' work would serve a purpose if sufficient resources were generated to allow communities to make the trademark widely known among consumers. Non-living works could be protected either through a global trademark authority or through national or regional trademarks.

An example of something like this is found in the United States, where protection may be given under federal law to landscapes or landforms that are linked to historic events with the potential to yield important information, or that represent a characteristic human activity or environment. This may include locations where indigenous peoples gathered foods or medicines, and landforms associated with indigenous cultural traditions and religious practice[2].

The existing intellectual property system, therefore, is biased toward the largest enterprises with the strongest legal departments.

Patents

Within the framework of standard intellectual property protection mechanisms, the industrial patent system is the only system that could afford reasonable protection for indigenous knowledge related to living materials. Yet this system was designed in the era of the Industrial Revolution to protect factory machinery and does not necessarily meet the needs of either the biotechnology industry or indigenous communities.

At a meeting of African research institutes hosted in Nairobi by the African Academy of Sciences in 1989, the president of Research Corporation (a US nonprofit agency with a mandate to work with public universities to patent and commercialize academic research) provided an overview of the potential licensing royalties that could arise from patentable research. He noted that the costs of the meeting probably exceeded total potential Africa-wide royalty revenues over a ten-year period. In the North, every million dollars in research is expected to yield one publishable paper. One in every hundred such papers leads to a patent application; one in every hundred patents might produce notable revenue and only one out of a thousand patents brings bonanza profits.

For the cooperative innovation system, the ratio is not likely to be better. Moreover, the cost of patent protection is likely to be high. British industry experts have estimated that 8 to 9 percent of corporate R&D budgets is spent up front on legal fees and other costs to ensure protection and undertake litigation. The average cost of litigation over patents in the United States has risen from a quarter of a million dollars 20 years ago to well over a million dollars today. Since patents are dealt with under civil law, the burden of these expenses rests with the patent holder. The existing intellectual property system, therefore, is biased toward the largest enterprises with the strongest legal departments.

Although there is a growing assumption that indigenous knowledge could be protected under intellectual property law, there is still controversy about the value of using IPRs for medicinal plants or for farmers' folk varieties (see box II for a summary of the current international debate). In RAFI's analysis, the cooperative innovation system could succeed in winning the right to establish patent claims over biological products and processes; indeed, developed-country industries and IPR institutions might even support this objective and encourage patent applications. But it is likely that the economic benefits of such protection would be negligible in most situations most of the time. Adopting the current model of IPRs could divert attention and energy from more useful initiatives.

Alternative Patent Initiatives

Instead, indigenous communities and concerned governments and non-governmental organizations could work within the present IPR system in a number of ways:

New Deposit Rules. National regulations and, where appropriate, international conventions, could be altered to ensure that all inventions deposited for the legal record in gene banks or cell libraries must include passport data identifying all available information about the origin of the material, including, where appropriate, the names of individuals and of communities that have contributed material (or information related to material) on deposit. The same information should be attached to all patent applications. Failure to disclose such information or any bad faith effort in disclosing information should lead to forfeiture of any patents emanating from the material.

Gene Bank Accessions. Material held in gene banks and cell libraries whose passport data indicates that it has been collected from indigenous communities should be regarded as forming part of the intellectual integrity of indigenous peoples; no part of that material should be subject to patent claims by others. Effectively, this material should be regarded as "published" information precluding patent applications.

IPR Ombudspersons. Recognizing that the existing intellectual property system could contribute to the piracy of innovations by indigenous communities, each national patent office and the secretariat for each IPR convention, especially UPOV and patent conventions, should create the post of ombudsperson whose task it would be to investigate complaints from indigenous communities, and governments and organizations acting in consultation with indigenous communities. The ombudsperson post should be filled in consultation with indigenous organizations; the person should provide an annual report on her/his activities. The ombudsperson should have the authority to delay patent approvals and to require the review of specific patents or patent applications.

Tribunals. Where indigenous communities challenge a patent claim through the ombudsperson or by other available means, a tribunal or patent court should be held to resolve the dispute. The annual report of the office or convention acting on the dispute should provide full information on the status of the dispute.

IPR Expenses. The costs of deposit and disclosure as well as the expenses related to the office of the ombudsperson, tribunals, and legal representation for indigenous communities should be borne through the fee structure for intellectual property rights in each jurisdiction. Where the ombudsperson determines that grounds exist to dispute a patent claim, indigenous communities should be afforded all necessary legal support as part of the normal operating budget of the patent office.

Other Initiatives. New areas of intellectual property discussion such as the debate over product liability, criminal law enforcement, and reverse burden of proof (see section one of this report), should they come into effect in any jurisdiction, should be reviewed for their potential utility to safeguard the intellectual integrity of indigenous communities. There is a strong case to be made that the uncompensated appropriation of farmers' varieties and medicinal plants constitutes real theft and that the parties responsible should be pursued under criminal law at the expense of national law enforcement agencies in the countries where the theft occurs (the patenting country).

These measures would not represent a significant departure from the current work of the intellectual property system and would not constitute an unacceptable burden on that system. It is current practice for patent offices to as-

Box II: The cooperative innovation system versus the institutional innovation system

Conventional "North" Arguments:	Conventional "South" Arguments:
The Natural Phenomena Argument: Landraces are the result of a combination of environmental & human selection pressures over millennia. Most of the credit goes to the environment and a little goes to a hundred generations of farmers.	Folkseeds are well-adopted/bred for specific micro-ecological niches. In a sense, they are "sustainable agricultural development" functioning in balance with nature, providing relatively-secure food and requiring no (or few) external inputs.
Expiry date Argument: IPR for a landrace is like trying to patent the wheel a few thousand years after publication. This would amount to an inexcusable monopoly under normal patent systems. The "best before" date has expired.	The folkseed in the field is no less "modern" (or more "traditional") than the latest hybrid maize release. Each is the up-to-date manifestation of ongoing plant breeding.
The Invisible Inventor Argument: Who would receive the protection? What farmer from what country as defined at what point in history?	The local farm/ethnic community could be recognized. Compensation, however, is best through a global funding mechanism on a program and project basis not tied to individual communities or even countries.
The Commercial Irrelevance Argument: Why bother? Almost everything collected has almost zero commercial value. It will cost as much (or more) to monitor germplasm flows than farmers will benefit through compensation schemes.	Most patents have little or no economic value. One in a hundred has value and one in a thousand has enormous value. The same is probably true of folkseeds, except that a low commercial "return" in Northern terms can be a huge return for Southern farmers.
The Hidden Genius Argument: Where a landrace is used, breeders almost always extract and adapt a gene or gene complex which becomes one of several hundreds of components in a new variety. The useful properties extracted from the material may not have been known, or valued, or even expressed in the farmers' field.	Recent biotech patent decisions (Agracetus and cotton; PGS and Bt) imply that the rights holder doesn't need to know everything about the patented material in order to benefit.
The Invisible Hand Argument: Farmers are best served by a free flow of germplasm ensuring access to breeders' innovations. Efforts to assign benefits and provide compensation for their "raw" material will just slow innovation and restrict the spread of future benefits.	This is the "Father Knows Best" or Trickle-Down-upon Neo-colonialist Approach. The Northern equivalent would be for governments to tell corporations that "Governments Know Best" about distributing marketplace benefits.

sign the full cost of their offices on the fee structure imposed on applicants. The modest cost of these proposals, therefore, would simply become a slight additional part of the "cost of doing business" in the IPR community.

Sui Generis IPR Systems

Another possibility involves the adoption of *sui generis* forms of intellectual property protection specifically designed for plant varieties and animal breeds.

Inventors' Certificates

Indigenous communities and many governments are not aware that IPR systems include a number of options that do not imply exclusive monopoly control over inventions. Among these are Inventors' Certificates, which can discard financial compensation altogether in favor of non-monetary awards and non-exclusive licensing arrangements. Developing-country governments and indigenous communities could find it useful to explore possibilities for further innovation in this area.

Governments can establish Inventors' Certificates through uncomplicated national legislation; they need only notify WIPO and GATT that this legislation exists. Forms of recognition or compensation can be determined either through legislation or through regulation and can vary by category or by case. Governments can adjust the terms of compensation to promote local innovations in domestic or export markets or to attract a foreign invention where access to that invention is deemed to be in the national interest.

Inventors' Certificates would allow governments the flexibility to:

- Vary the methods of recognition;
- Permit or exclude monetary compensation;
- Grant exclusive or non-exclusive licenses;
- Ensure that the patented technology be applied/manufactured nationally;
- Establish other transfer of technology conditions beneficial to the importing country;
- Vary the period of protection;
- Attach any other contractual provisions deemed beneficial.

Inventors' Certificates can also be assigned to indigenous communities with the same flexibility as for imported inventions. Other countries allowing Inventors' Certificates would be expected to respect those awarded for indigenous knowledge.

The Model Law on Folklore

The Model Law on Folklore, adopted in 1985 by both UNESCO and WIPO, affords indigenous communities three unique elements that are especially appropriate to the protection of biological products and processes. First, "communities" (rather than specific individuals) can be the legally registered innovators; they can either act on their own behalf or be represented by the State. Second, community innovations are not necessarily fixed and finalized, but can be ongoing or evolutionary and still be protected by intellectual property law. And third, communities retain exclusive monopoly control over their folklore innovations for as long as the community continues to innovate.

The law has been interpreted to exclude scientific inventions. However, standard IPR law in most countries expressly excludes protection for plants, animals, pharmaceuticals, and chemicals, but many national patent offices have interpreted the law to permit the patenting of such innovations on the assumption that if legislators had known "then" what they know "now," they would not have made these exclusions. The same argument could apply to the inclusion of indigenous knowledge.

The Model Law, which is not, but could still be formalized into a legally binding international convention, acknowledges the concept of ongoing indigenous community innovation. It does not, however, offer any obvious means of safeguarding community innovations — a practical problem that plagues all efforts to utilize the existing IPR framework. Nevertheless, the Model Law could either be expanded to include protection for the cooperative innovation system or it could serve as a precedent for including such protection in other conventions, particularly the Union for the Protection of New Varieties of Plants or the Industrial Property Convention (both currently under revision).

Blank Cassettes Precedent

The experience of the recording and publishing industries is relevant for determining whether remuneration for folklore is workable. Several countries have passed laws that place a surcharge on the sale of blank cassette tapes (and some on library photocopiers). The revenues revert to a special fund which is then distributed to recording artists, authors, and publishers) on a formula basis. The assumption is that almost all blank cassettes (or library photocopiers) are used to duplicate copyright material.

This example from industrialized countries could serve as a principle for establishing a general fund for the remuneration of folklore while avoiding the complications of specific attribution. Managed as a Trust Fund through a United Nations agency, the resources generated could be distributed on the merits of program and project proposals submitted by indigenous peoples' organizations around the world. The objective of the fund would be to support the conservation and development of community innovation. This proposed fund is similar to an FAO proposal for a fund related to farmers' rights.

Bilateral Contracts

The Convention on Biological Diversity and other private initiatives have encouraged developing countries and indigenous communities to seek bilateral contractual agreements with private companies in return for access to germplasm. In general, the movement toward negotiated bilateral deals is worrisome in that it pits a large number of developing countries (and indigenous communities) with varying amounts of biodiversity against a relatively small number of corporations able to take full advantage of bio-materials.

Materials Transfer Agreements, etc.

This form of bilateral agreement treats genetic material as a commodity rather than as knowledge; a contract is reached between buyer and seller based on the potential value of the commodity. Such contracts generally involve both initial "up front" payments and a formula for additional payments if and when the material is commercialized. Such agreements are inevitable in situations where both parties realize that the material to be transferred has real (and relatively immediate) commercial potential. For example, rust-resistant coffee germplasm from Ethiopia or high-quality cacao from Brazil may always demand a premium over and above any general international arrangement. Such agreements can have a role to play in the protection of the interests of indigenous communities.

A Materials Transfer Agreement would be expected to contain the following provisions:

- Initial payment for specific germplasm;
- Reporting provisions advising the community of the research related to the germplasm;
- Transfer of technology arrangements giving both parties access to technologies related to the germplasm;
- Third Party agreement regarding the conditions (if any) under which germplasm or research products can be made available to third parties;
- Commercialization agreement setting out the terms and conditions under which germplasm or research products may be commercialized. Such provisions could include royalties or other financial arrangements;
- Arbitration agreement establishing dispute settlement procedures; such procedures should ensure that the legal costs of dispute settlement or litigation are financed by the corporation through the agreement,

- ◇ Review process, through which either party can have the terms of the agreement reviewed independently for its fairness at any time during the life of the agreement.

These agreements should not be confused with agreements in which communities become involved in commercial plant extraction. Agreements under which communities extract plants for commercial purposes involve a serious risk that communities become trapped in a system of exploitation in which they lose all control over their own livelihoods. An interesting example of such a case is that of the Guajajara in Brazil who became involved in the gathering, for a company called Vegetex, of a plant called Pilocarpus Jaborandi which is used in the production of eye drops for the treatment of glaucoma. By 1989 many men of the community had become underpaid wage workers completely susceptible to the caprices of the company[3].

Bio-Prospecting

Bilateral bio-prospecting agreements, in which a country or community provides access to biodiversity and/or knowledge on agreed terms, are not likely to provide adequate compensation to either indigenous peoples or developing countries unless they are made within the framework of broader intergovernmental arrangements. Merck Pharmaceutical's arrangement with Costa Rica illustrates the point. The deal requires Costa Rica to provide Merck with roughly 10,000 plant, animal or microbial samples in return for US$1.3 million or $130 per sample[4]. Costa Rica is estimated to hold five percent of the world's biodiversity[5]. If the Merck deal were replicated for the developing world as a whole, all the South's biodiversity would go for $20 million. Merck's sales in 1991 alone were $8,600 million, while Costa Rica's entire Gross National Product that year was less than $5,200 million[6]. Merck's research budget in 1991 was roughly $1,000 million. At present, Merck has three drugs on the market with a sales volume in excess of $1,000 million each. Since Merck invests an average of $125 million on research for each new drug, the discovery charge for one single new drug arising from the Costa Rican agreement is barely loose change for Merck. For Merck, the Costa Rica contract is cheap labor. If 10 or 20 years from now, Merck and Costa Rica dispute the origins of a plant-derived active ingredient, the country has comparatively little capacity to appeal to the international courts to resolve such a dispute compared with Merck's army of lawyers.

Conservation Compensation

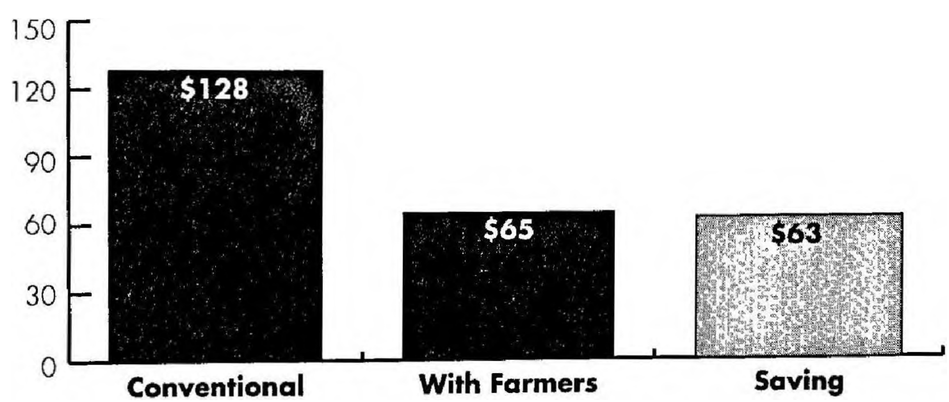
The international community needs to understand and recognize the extent of the real scientific contribution indigenous communities can make and are making; it must find ways to compensate those communities for their knowledge and work.

The Keystone Initiative

In the context of plant genetic resources, developing countries have taken the position at the UN Food and Agriculture Organization that the best method of compensating farmers for their plant breeding efforts is through "farmers' rights." These rights encompass all aspects of plant genetic resources including Germplasm, Information, Funds, Technologies, and Systems (GIFTS) that are necessary to make any raw material a usable resource; the GIFTS are ensured through a consistent international funding mechanism. Funds are used not to compensate individual farmers or indigenous peoples but to reward meritorious work that encourages conservation and use primarily in developing countries.

This approach was first proposed in 1991 by the Keystone International Dialogue on Plant Genetic Resources (1988-91), which recommended a $300 million per year budget for the first seven years. The Keystone participants agreed that the fund should be mandatory and automatic and that it should be channeled through a UN agency. Great importance was given to the role of indigenous farming communities in collecting, conserving, and developing plant genetic resources.

Figure VI: The costs of germplasm storage in gene banks and in-situ



Source: Based on figures from the Final Consensus Report Global Initiative for the Security and Sustainable Use of Plant Genetic Resource. Keystone International Dialogue Series on Plant Genetic Resources. Third Plenary Session 31 May - 4 June 1991, Oslo, Norway.

Although the Keystone initiative was limited to agricultural plants, the basic principles could be extrapolated to all biological products and processes nurtured by indigenous peoples. Perhaps its most attractive feature is the elimination of legal mechanisms for intellectual property protection. Indigenous communities could be compensated on the basis of development needs and opportunity, without reference to law courts, patent offices, or legal departments. Even at the modest level of $300 million per annum, the resources would far exceed what would be available through bilateral negotiations such as between Merck and Costa Rica.

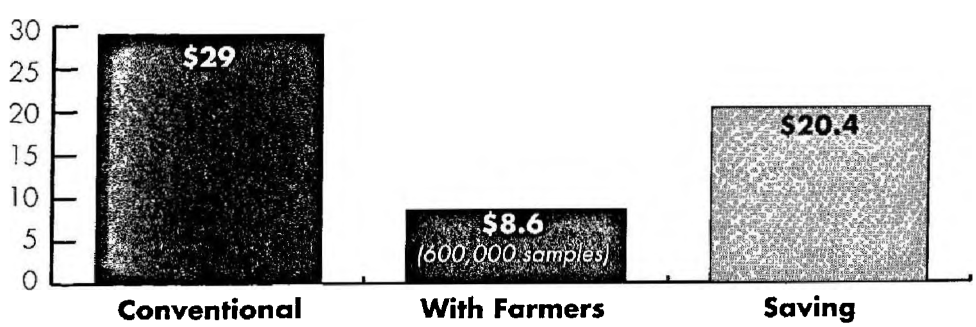
Community Contribution

Following the recognition at Keystone and at FAO that indigenous rural communities have an essential role in plant genetic conservation and enhancement, RAFI has taken the Keystone budget figures and worked with a number of scientists to determine the realistic support that farmers could offer the conservation effort to conserve plant genetic diversity in agricultural species.

The cost in the institutional system of doubling the number of crop germplasm accessions in gene banks would be at least $29 million. With the active participation of indigenous communities, the cost could be cut by about $20 million; indigenous rural communities could directly collect more than 600,000 accessions (see Figure VI).

A fundamental tenet for the involvement of indigenous communities in germplasm conservation is that full samples are stored securely within the com-

Figure VII: The costs of germplasm collection by gene banks versus collection by communities



Source: Based on figures from the Final Consensus Report Global Initiative for the Security and Sustainable Use of Plant Genetic Resource. Keystone International Dialogue Series on Plant Genetic Resources. Third Plenary Session 31 May - 4 June 1991, Oslo, Norway.

munities themselves, i.e., *in-situ* conservation. This is not merely a moral principle but also a scientific necessity if the integrity of samples is to be preserved. Moreover, many species resist gene bank storage and can only be protected in field gene banks.

RAFI estimates that the cost of germplasm storage (under current gene bank conditions and at current costs) in the seven years (1993-2000) proposed by the Keystone initiative would be not less than $128 million. With the active participation of indigenous rural communities, these costs would be almost halved (see Figure VII).

Intellectual Integrity Framework

The common objective shared by most indigenous communities is to nurture and protect indigenous knowledge. It is our understanding that most communities would prefer a framework mechanism that would allow them to ensure the intellectual integrity of their ongoing innovations rather than to obtain intellectual property. Ultimately, a combination of initiatives, that could collectively be termed the "intellectual integrity framework" may prove most appropriate. This framework would involve some aspects of each of the various proposals plus the additional ones cited below.

Intellectual Protection

UN agencies and other parties could work with indigenous communities and national governments to ensure that the proposals cited above on deposit rules, ombudsperson, tribunals, etc., are established at least within the world's major patenting regimes (France, Germany, Japan, the United Kingdom, and the United States). Indigenous communities need neither endorse nor support intellectual property systems in order to have their intellectual integrity protected. UN and other agencies could work with indigenous communities to expand upon these proposals and encourage their discussion in regional and national fora.

Intellectual Recognition

New initiatives are needed to assist indigenous communities and their organizations to counter the ongoing assumption in the scientific community and society at large that indigenous knowledge is either "quaint," "quackery," or "quits." There will be no significant support for the conservation and development of cooperative innovation systems until the real utility of this knowledge in the context of today's social, scientific, and environmental problems is understood by both scientists and the general public. A public information campaign should be accompanied by a scientific information campaign directed to the institutional innovation system. The exact nature of this campaign should be developed under the direction of indigenous peoples' organizations.

It is equally important, however, to provide indigenous people with key information on issues related to intellectual property/integrity and the value of bio-materials.

Intellectual Development

Indigenous peoples' organizations and communities urgently need support to extend their existing systems of information-exchange and cooperation. It is now possible to establish efficient and relatively inexpensive closed-circuit information systems and "libraries" that make it possible for communities to document and control access to their knowledge. Linkages can also be made among indigenous peoples to allow for a closed exchange system. UN agencies could play an important role in assisting indigenous people in this work and bringing their organizations in contact with other bodies undertaking research in this field.

Intellectual Exchange

Each of the various policy options could be developed further. But it is important that indigenous peoples' organizations quickly become active participants in this discussion before much more work is done. Much of the information contained in this report is new, and it may well serve to alter the perspective of many readers. Indigenous peoples need to have early access to this kind of information as a prelude to policy formulation. As a first step, indigenous communities should meet to discuss their policy choices at least at the regional level. Two- and three-day workshops in each region of the world could help establish a realistic understanding of the current situation and the real opportunities.

Summarizing, the following actions should be considered by multilateral organizations, governments, non-governmental organizations and other stakeholders:

- Further study of Inventors' Certificates and Materials Transfer Agreements as a means of compensating indigenous communities and of safeguarding the intellectual integrity of these communities.
- Further development of the Model Law on Folklore by both UNESCO and WIPO with a view to encouraging national legislation and an international convention in support of indigenous knowledge.

- The possibility of establishing a special trust fund for the remuneration of indigenous knowledge on a program and project basis as part of FAO's Farmers' Rights initiative.
- A study of Materials Transfer Agreements and specific contracts with a view to establishing a series of model agreements that may be considered by governments, corporations, and indigenous communities.
- A discussion of the role of indigenous communities in *in situ* conservation with FAO, the Consultative Group on International Agricultural Research and in the context of the Biodiversity Convention.
- The preparation of a popular information kit to provide key information to indigenous people. It should be prepared in close collaboration with key organizations and it should form the basis for seminars and discussions within indigenous peoples' organizations and communities.
- The convening of a meeting with indigenous organizations and informatics experts to discuss needs and means for safeguarding the development of indigenous knowledge and its exchange with others.

END NOTES

Chapter I.

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APPENDIX A

The North — Benefiting From Biodiversity

100 Examples of the South's Contribution to the North's Development

To improve our understanding of the value of Third World germplasm and the contribution of rural communities, RAFI has compiled a list of more than 100 instances where local knowledge has made — or is making — a contribution to agriculture, food processing, or pharmaceutical development in the North. This is not a roster of all benefits from all parts of the world to all parts of the world. It is solely a list of proven or potential contributions made by the South to the North. The South may also be benefiting.

Country/Region to...	Species:	Discussion:
South to USA	General	The US government estimates that every 1% gain in crop productivity brought about through the use of exotic germplasm means a $1 billion benefit to the American economy[1].
Mexico to USA	Maize	An almost extinct form of perennial teocinte (an ancestor of maize) protected by a Mexican farm family may save farmers $4.4 billion per year[2]. The US crop is valued at more than $10 billion per annum[3].
Ethiopia to USA	Barley	Farmer-derived Ethiopian barley is worth $150 million in the United States each year[4]. The annual value of the American crop is more than $670 million[5].
Near East to Germany	Barley	A barley variety collected in the Near East became the parent of a major German variety "patented" by the Max Plank Institute in 1965. The variety, Volgersamen Gold, dominated the $1 billion German barley market for several years.
North Africa, Ethiopia, South Asia, to Denmark	Barley	Danish breeders developed barley varieties resistant to powdery mildew in the late 1960s, thus preventing crop losses amounting to $200 million in the period 1967-1974. Resistant germplasm came from farmers in North Africa, Ethiopia, and Southern Asia[6].

Country/Region to...	Species:	Discussion:
Algeria, China, Egypt, to Canada & USA	Barley	North American barley has also depended heavily on the contributions of farmers in Algeria, China, and Egypt to provide disease-resistance[7].
South (CIMMYT) to USA	Wheat	In 1984, 21% of the US wheat crop was dependent upon "Green Revolution" germplasm. The share of semi-dwarf wheats in the US crop doubled over the previous decade and was still growing[8]. The value, estimated by the OECD in 1982, was not less than $500 million. The total value of the American crop is approximately $6 billion per year[9].
South (CIMMYT) to North	Wheat	26% of all CIMMYT wheat nursery trials are conducted for industrialized countries and are regarded, by these countries, as a major benefit to their own wheat breeding programmes[10].
Brazil (CIMMYT) to North	Wheat	An old Brazilian wheat variety has been found by CIMMYT to confer unusually durable resistance to leaf rust in new wheat varieties. Leaf rust costs millions of dollars per year and plagues crops in the South and North[11].
Turkey to USA	Wheat	A wheat sample from Turkey is valued at $50 million per annum in the US Northwest[12].
South (CIMMYT) to Italy	Wheat	Italian scientists have valued the annual contribution of CIMMYT durum wheat material at nothing less than $300 million.
South (CIMMYT) to New Zealand	Wheat	New Zealand's modest wheat industry has gained well over $5 million in seed from developing countries since the creation of the international germplasm board in 1974.
South (CIMMYT) to Australia	Wheat	Australian authorities have valued the contribution of wheat seed from one such gene bank in Mexico (CIMMYT) at $75 million per year.
South (ICRISAT & ICARDA) to Australia	Chickpeas	Australia's multi-billion dollar livestock industry has benefited from 16,000 chickpea seed samples collected through

Country/Region to...	Species:	Discussion:
		the Green Revolution centers in Third World countries.
Libya to Australia	Lucerne (Alfalfa)	Plant collector Clive Francis of Australia violated his contract and pocketed lucerne (alfalfa) seed he was sent to study in North Africa and, returning to Australia, now claims the seeds are "worth millions" to his country's livestock industry.
Afghanistan & Saudi Arabia to North	Lucerne (Alfalfa)	Lucerne variety AWPX3 traces its origins to genetic contributions from nine countries including Saudi Arabia and Afghanistan[13].
North Africa to Canada	Oats	North African farmers saved the Canadian oat crop from disaster in the 1970s[14].
South (CIMMYT) to private companies	Maize	About one-third of all maize germplasm requests made to CIMMYT comes from private companies. Interest in tropical maize germplasm is increasing enormously among major seed companies[15].
South to USA	Maize	An early 1980s study indicates that only one-tenth of one percent of US maize production was based on tropical maize germplasm. The study, however, also reported that private companies were increasing their use of exotic maize and that the share of the US crop could rise to 15% or higher within a few decades.
West Africa to USA	Maize	The only genetic resistance to Southern Corn Leaf Blight, a disease that caused $1 billion in damages in the United States in 1970, was found in a farm field in West Africa.
South (IRRI) to USA	Rice	IRRI rice germplasm contributed to at least 16% of the total US rice harvest in 1984 and the IRRI share was expected to increase[16]. The US crop is estimated to be work at least $1.1 billion each year[17].
South (IRRI) to private company	Rice	CB-801, a rice variety receiving a US Plant Variety Protection certificate (patent) in 1985 was described by USAID as "an IR8 derivative." The "patent" is held by The Farms of Texas Co[18].

Country/Region to...	Species:	Discussion:
South (IRRI) to Cornell – private companies	Rice	Rice research financed by the Rockefeller Foundation and involving the co-participation of IRRI and several Asian countries as well as Cornell University has led to Cornell patenting a number of rice probes and markers and selling non-exclusive licenses to biotech boutiques in the United States. The licenses sell for $1,000 each. Rockefeller designated Cornell as the repository and distributor of the collected wisdom of IRRI and Asian researchers[19].
Chile (CIAT) to France	Beans	CIAT (the International Centre for Tropical Agriculture in Colombia) is negotiating intellectual property rights over two new bean varieties with a French public sector institution. Royalties will be disposed of by CIAT. Officials concede that one of the varieties is based heavily on a Chilean accession in their gene bank and have wondered if they should turn over the profits to Chile[20].
South (CIAT) to USA	Beans	CIAT (working with beans) claims that its contribution to US agriculture is at least $60 million per annum.
South (ICARDA) to Australia, Spain, & Portugal	Barley	Barley varieties based on breeding material from ICARDA were released in Australia, Spain, and Portugal in the 1980s. Portugal also obtained bread wheats and durum wheats from ICARDA during this period[21].
South (ICARDA) to France, Italy, Portugal, & Spain	Chickpeas	Kabuli chickpeas, based on ICARDA material, were released in France, Italy, Portugal, and Spain. ICARDA-based lentil varieties were also released in Canada and Australia and Portugal obtained ICARDA's Faba beans[22].
Korea to USA	Soybeans	Soybeans from Korea are worth $100-$500 million to US farmers annually[23]. The crop is valued at more than $11 billion a year in the USA[24].
Near East to Europe	Beets	Wild beets collected in 1925 and in 1935 were discovered in 1983 to confer crop resistance to new root diseases in Europe's sugarbeets[25].

Country/Region to...	**Species:**	**Discussion:**
Nepal to UK	Brown Mustard	Nepal has donated the genes necessary to increase the pungency in born mustard grown in Britain[26]. China to UK Cherry Cherry germplasm provided by Chinese farmers saved the British industry some years ago[27].
Brazil to Europe	Potato	The Polo potato of Brazil has been used for breeding new varieties in Europe.
Andes to private companies	Potato	An orange potato from the Andes is being studied by the US snack food industry as a potential novelty potato chip in a very lucrative market[28]. (The global seed tuber market is estimated at $8.5 billion[29].)
South (CIP) to private companies	Potato	In 1991, the International Potato Centre (CIP) in Peru signed a contract with Plant Genetic Systems of Belgium to trade gene bank material for access to a transgenic potato resistant to potato tuber moth that was derived from that material. PGS has exclusive rights to the germplasm in industrialized countries and CIP has the right to use the material in the South. For the first time, CIP is obliged to refuse requests for this germplasm from the North[30].
South (CIP) to private company	Potato	A Pepsico subsidiary, Frito-Lay, was allowed to come to CIP to screen gene bank accessions for potato chip processing qualities. Frito-Lay took useful germplasm samples back to the United States and is now developing proprietary (patentable) varieties which could be marketed in such countries as Korea and Taiwan where Frito-Lay has large operations. CIP traded access to the gene bank for access to (some or all of) Frito-Lay's screening documentation[31].
South (CIP) to private company	Potato	EscaGenetics, another US ag biotech boutique, has also obtained germplasm from CIP which it is turning into patentable material. EscaGenetics is testing its new potatoes in a number of developing countries including Egypt[32].

Country/Region to...	Species:	Discussion:
Peru to USA	Tomato	Two wild tomatoes gathered in the Peruvian Andes contribute $5 million per annum to US processors.[33 34] (The global market for tomatoes is $3.5 billion[35] of which more than $1 billion is in the United States[36].
Philippines to USA	Tomato	A tomato collected in the Philippine uplands has been used to breed cold tolerance into US tomatoes.
Galapagos Islands to private companies	Tomato	A wild tomato from the Galapagos Islands sporting a jointless fruit stalk is worth millions of dollars a year to the mechanized tomato harvest in the USA[37].
South to Cornell	Tomato	Cornell University has patented a new class of compounds, derived from wild tomatoes, that can be used for a very wide range of toiletry items including sunscreens, lipstick, and shampoos[38].
Ethiopia to USA	Sorghum	Sorghum from Ethiopia is worth $12 million a year to US growers[39]. Annual value of the crop in the United States is above $1 billion[40].
India, Korea, and Myanmar to USA	Cucumber	US cucumbers depend upon germplasm from India, Korea, and Myanmar[41].
Mexico, Syria, Chile, & El Salvador to USA	Bean	Farm communities in Mexico, Syria, Chile, and El Salvador have all contributed disease-resistance germplasm to the American bean crop[42].
Iraq, Peru to North America	Pea	Iraqi and Peruvian farmers have joined forces to provide disease-resistant pea strains to North America[43].
India, Iran, and Manchuria to USA	Spinach	The California spinach crop owes its survival to farmers in Iran, Manchuria, and India[44]. The crop is valued at well over $300 million per annum in the United States[45].
Asia to private company	Neem tree	Agri-Dyne Technologies has patented two bio-insecticides derived from the neem tree – a plant famous for its medicinal and insecticidal properties in southeast Asia[46].
India to private companies	Neem tree	WR Grace and PJ Margo Co. of Karnataka, India are jointly-producing

Country/Region to...	Species:	Discussion:
		neem-based bio-pesticides in a new facility in India. Capable of processing 20 tonnes of neem seed per day, the two firms estimate the global market for their products could reach $50 million per annum by the end of the century[47].
Costa Rica to USA	Bacteria	The University of Massachusetts is patenting a bacteria collected from Costa Rican soil that has useful nematicidal and antifungal properties. (Crop losses caused by 100 strains of nematodes are estimated at $6 billion per year in the United States and $75 billion worldwide[48].)
China to Europe	Pig	China's Taihu pig, long famous for its hardiness, multiple-births and rapid growth rate, is being developed in both Europe and the United States to be bred into other porcine varieties[49].
East Africa to Australia	Bovines	Australian breeders recently introduced East African cattle breeds in order to improve the local stock[50].
West Africa to USA	Bovines	West-African bred N'Dama cattle have been crossed with Britain's Red Pol breed to create Senapol, a new and hardy breed now being used in, among other places, the southern United States[51].
Africa to Europe, North America	Bovines	Other African breeds have made a major contribution to US and European herds through increased disease resistance and other qualities such as shorthorns[52].
South (ILRAD) to private companies	Vaccine	ILRAD (the International Livestock Research and Development Centre in Nairobi) has taken out a patent on a live vaccine for East Coast Fever. Contrary to stated CGIAR principles, the patent was not taken out to prevent usurpation by others but to stimulate a market for the vaccine. The very first "live" CG patent thus breaks the "rules of the game" laid down by CGIAR. ILRAD has a board member from Merck (one of the world's two largest pharmaceutical com panies)[53].

Country/Region to...	Species:	Discussion:
Brazil to USA	Fungus	Florida scientists recently patented a strain of fungus identified by Brazilian farmers as being death on fire ants. The ants cause hundreds of millions of dollars in crop damages in the United States.
India & Mexico to USA	Rubber	US researchers are working with an ornamental plant from India, the guayule plant from Mexico and the U.S. southwest and traditional Brazilian rubber to bio-synthesize a new natural rubber that can grow commercially in the United States[54]. (If successful, the market value will be in the hundreds of millions per annum.)
West Africa to private companies	Cowpea	A pest-resistant cowpea variety originating in West Africa was taken from IITA in Nigeria to Durham University and the CpTi gene was ultimately patented by Agricultural Genetics Co. of the UK and licensed to seed and biotech companies.
West Africa to private company	Cowpea	Agricultural Genetics Co. has also developed a method for extracting animal vaccines from transgenic cow pea plants by infecting the Cowpea Mosaic Virus with antigenes. One leaf of a two-week-old cowpea can vaccinate 200 animals, reducing current inoculation costs substantially. The first vaccine Agricultural Genetics is developing is for foot and mouth disease. Worldwide patent rights have been applied for[55].
Ethiopia to private companies	Endod	The University of Toledo is patenting Ethiopian research related to the endod (soapberry) plant used in Africa as a shampoo and detergent. Endod also appears to be safe and effective against zebra mussels that have infested the Great Lakes and are expected to cause damages of $5 billion by the year 2000[56].
West Africa to U.S. universities and private companies	Thaumatin	The University of California and Lucky Biotech have applied for patent rights over genetically-engineered thaumatin

Country/Region to...	Species:	Discussion:
		sweetener in industrialized countries and in West Africa. The plant has long been used as a sweetener in Africa.
Uruguay to USA	Nematodes	The University of Florida has patented Uruguayan nematodes and, in turn, has licensed BioControl, Inc. to market the nematodes for use on golf courses and sporting turf.
India to USA	Bajra	Bajra, a small grain grown in India, is yielding up to one-and-a-half tons per hectare on sand nurtured with seawater. The US National Research Council and the biotech industry are interested in saline-tolerant plants such as Bajra in order to grow crops on coastal plains and other areas that now are often not usable. In addition, genetic material from saline-tolerant crops might be transposed into major crops to increase their viability on poorly-irrigated lands[57].
Africa to USA	Tilapia fish	Africa's Tilapia fish (sometimes known as the "aquatic chicken") have been transferred and bred for use in many parts of the world, including the United States and Europe[58].
Southeast Asia to USA	Algae	Algae gathered from the China Sea region are spawning a whole new industry on the Carolina shores of the US.
Zambia & Zimbabwe to Australia	Bovines	Embryos of 269 Tuli and 264 Boran cattle from Zimbabwe and Zambia were brought to Australia in 1990 to improve local Frisian herds with higher fertility levels, docility, and environmental stress resistance. Using multiple ovulation and embryo transfer techniques, the imports have been hailed as the saviors of the northern Australian cattle industry.
South to North	Bovine Growth Hormone testing	Bovine Growth Hormone (also known as BST) is being test marketed in Latin America, Africa, and Asia although it is still illegal in Europe and North America. (The ultimate value to the global dairy industry is estimated by

Country/Region to...	Species:	Discussion:
		Monsanto, a major player, at $1 billion per annum. The low estimate is $400 million.) If the product is finally commercialized in industrialized countries, developing countries will have been the guinea pigs[59].
Colombia & Peru to private companies	Cotton	Farmer-bred cotton varieties from Peru and Colombia containing natural colours of browns and violets have been further developed, and patented, in the United States. US breeders concede their invention is not "new" but argue that they have done considerable work to commercialize the varieties now being produced under contract to jean-maker Levi Strauss. It is illegal to grow these traditional varieties in Peru and many varieties have disappeared locally[60].
Latin America to private companies	Amaranth	Amaranth varieties based on material originating in Latin America, have been patented in the United States and are now being marketed in Mexico and Peru where farmers are being forced to pay royalties on their own inventions[61].

Country/Region to...	Medicinals:	Discussion:
Near East to private company	Spiraea plant	Derived from a traditional Arab medicinal plant, Bayer's synthetic aspirin is the most widely used drug in the world. More than forty million pounds are produced annually in the US — almost a pill a person a day[62].
Andes to UK	Cinchona	Cinchona bark from the Andes is the basis for the anti-malarial drug, quinine, that lost much of its potency during the Vietnam War and is now being studied again by biotech companies.
China to North	Qing Hao	Qing Hao, a Chinese medicinal plant used to combat malaria for 2000 years, has been semi-synthesized by Phone-Poulenc Rorer and will be released, under patent, in Europe in 1993 as a new anti-malarial drug known as

Country/Region to...	Medicinals:	Discussion:
		Paluther. Glaxo is exploring properties of the same plant and WHO is testing plant derivatives in Asia and Africa[63].
Latin America & Africa to private company	General	Glaxo's Natural Products Discovery Department is looking for medicinal plants in Latin America and Africa[64].
Indonesia to private companies	*convolulaceae*	Tonen Corp. (a Japanese oil refiner) and Eisai (a Japanese drug company) are studying a compound drawn from a traditional Indonesian medicine tree (of the family, *convolulaceae*) for its ability to arrest the proliferation of HIV in infected mice. The tree is used for a range of health problems in Indonesia[65].
Peru to private company	tree	Hauser Chemical Research Inc. supplies a naturally-derived drug, from a Peruvian medicinal tree, to Cambridge Bioscience Inc. for use in Stimulon, now being tested as a potential AIDS vaccine[66].
Samoa to North	plant	A medicinal plant used in Samoa has been discovered to have a positive impact against the AIDS virus according to US National Cancer Institute researchers. Brigham Young University and the NCI are studying a plant that has been saved from extinction by Samoan herbalists[67].
Mexico to North	albahaca de monte (ocinum micranthum), pepeltun (cissampelos pareira) and la altaniza (parthenuim histerophorus)	Mexican scientists and companies are examining albahaca de monte (ocinum micranthum), pepeltun (cissampelos pareira), and la altaniza (parthenuim histerophorus) for their curative properties. Each plant has a long history in traditional medicine[68].
Nigeria to North	Monkeys	Researchers in the Okomu Forest Reserve in Nigeria have shown that rare monkeys endemic to the forest have similar blood constitution to humans, making them valuable for medical research and drug testing[69].

Country/Region to...	Medicinals:	Discussion:
Madagascar to North	Rosy periwinkle	Two drugs derived from Madagascar's rosy periwinkle earn pharmaceutical companies more than $100 million per annum as anti-cancer and childhood leukemia drugs. Allelix (a Canadian biotech firm) is working with Mitsui Pharmaceutical to develop "natural" periwinkle compounds that will not need Madagascar anymore[70]. (The leukemia drug has turned a cancer that used to kill 8 out of 10 victims into one where 8 of 10 children survive[71].)
Latin America to North	Pau D'Arco	Pau D'Arco, a medicinal plant from Latin America, has long been used to combat malaria and cancers. Its current market value is estimated at $200 million[72].
Latin America to North	Tecoma	Another Latin American plant used in traditional medicine, Tecoma, is now being studied for its potential use against diabetes[73].
Latin America to North	Stevia	Stevia, a plant used widely in Latin America as a sweetener and as an antacid and diuretic also seems to resist tooth decay and is being studied for its use in weight-loss regimes[74].
Argentina to private company	Bacteria	Mitsubishi has patented and marketed a streptomycin-based antibiotic isolated from Argentine soil. The antibiotic is to be added to poultry and swine feeds[75].
Latin America to North	Quassia	Used for a multitude of purposes as a disinfectant in hair rinses, a stimulant to appetite and to kill intestinal worms, Quassia is widely used in indigenous Latin American medicine and is being studied for uses in industrialized coun tries as well[76]. The Suma plant of South America has long been used for diabetes and some cancers and is now being looked at in the North for its cancer-fighting proper-ties[77].
Caribbean to	Microbials private companies	Muco-Search, a small US bio-explorer, charges $2,000 a "hit" for unique algae and fungi gathered up on the

Country/Region to...	Medicinals:	Discussion:
		beaches of Caribbean islands. The germplasm is sold to pharmaceutical and chemical houses in North America[78].
Latin America to North	Ipecac	Ipecac, an indigenous South American plant, has long been added to syrups to reduce lung congestion and as a cough medicine[79].
Brazil to North	Muira Pauma	Muira Pauma is a plant that has been used by indigenous communities in Brazil to cure impotency and to regulate the menstrual cycle. Scientists are now studying the plant for its ability to reduce cholesterol levels in the body[80].
Jamaica to North	Sponge	A Jamaican sponge has become the source of patented antiviral and anticancer drugs[81].
Brazil to North	Cephatis	Roots of Cephatis ipecacuana, a medici-ipecacuananal plant in Brazil, are being developed to treat dysentery.
China to private companies	plants	Xenova Co. (UK) has established an agreement with the Chinese Institute of Medicinal Plant Development and China's Institute of Botany to receive plant extracts and phytochemicals from traditional medicinal plants. Xenova will have exclusive rights outside of China and China will have rights internally and will receive royalties on Xenova's sales[82].
India to private company	plants	Ciba-Geigy of Switzerland hired local people to collect useful plants in the Bombay region of India and, according to MS Swaminathan, devastated the availability of at least one local species in the area[83].
Brazil to private company	tikluba	The tikluba plant, long used by the Ure-eu-Wau-Wau community of the Brazilian Amazon is currently being developed by Merck as an anti-coagulant.
South to North	*Derris trifoliate*	A climbing vine, *Derris trifoliate*, found in mangrove forests from Africa to Asia and onto the Pacific islands has leaves containing rotenone. This chemical is

Country/Region to...	Medicinals:	Discussion:
		extracted and used to eliminate competitors in fish ponds. The plant is now also being studied by the biotech industry for other uses.
South to UK	Shark	Shark bile is being tested by industry in the UK as a possible cure for severe acne[84].
Amazon to North	d-tubocurarine	An Amazonian plant, d-tubocurarine, used sometimes as a poison, is being developed as a muscle-relaxant.
Colombia to North falciparum	Plasmodium	Colombian researchers have developed a malaria vaccine derived from the parasite Plasmodium falciparum which has been tested on 30,000 Latin Americans and seems effective four out of five times. (Malaria causes 2 million deaths — mostly children — each year and afflicts more than 200 million people[85].)
Costa Rice to private companies	plants	Merck signed a $1 million (over 2 years) deal with Costa Rica for bio-prospecting rights to one-third of the country's land area[86 87].
South to private company	plants	Monsanto has signed a multi-million dollar agreement with the Missouri Botanical Gardens for bio-prospecting throughout the Third World[88].
China to private company	plants	Syntex and a Hong Kong University are engaged in a joint venture to screen traditional Chinese medicines for active compounds that could be incorporated into new biotech products[89].
Mexico to private company	barbasco	Syntex acquired its enthusiasm for medicinal plants in Mexico where it took advantage of local knowledge to use barbasco roots to make steroid hormones ultimately used in birth-control pills[90].
Malaysia & Pacific to private company	micro-organisms	Smithkline-Beecham is searching for plants, marine organisms and micro-organisms in Malaysia and the Pacific[91].
South to private company	General	In 1991, Monsanto began to advertise in its in-house magazine for vacationing staffers travelling to exotic places to bring back interesting biological samples[92].

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APPENDIX B

Macro biological Innovations of Indigenous Communities

A Sampling of Potentially "Patentable" Products or Processes Under the WIPO/Unesco Model Law on Folklore

Country/Region:	Crop:	Innovation:
Burkina Faso	Millet	A method of sexual reproduction by planting in holes with maize seeds.
Congo	Louboto tree	Because of very easy coppicing, a method of tree harvesting to produce strong, rot-resistant tools.
Congo	Paw-paw trees	A process for pruning treetops of males to change sex and lead to fruiting.
Congo	Safou	A method of "pole" cutting is virtually the only means of propagation.
East Africa	Banana	A method of suppressing male inflorescence to draw nutrients to female flowers and increase banana size.
Egypt	Sycamore Fig	A method of pricking the fig with an oiled needle to accelerate ripening.
Ethiopia	Ensete	A method for vegetative propagation through suckers and a complex of surgical and soil-related techniques.
Ethiopia	Leucaena	A method by which nitrogen-fixing Leucaena branches are woven into living fences that keep animals in and also act as fodder.
Ghana/Ivory Coast	Yam	A method of pyramid planting using leaves and earth, strengthening root system and protecting plant from high temperatures.
Madagascar	Ylang-Ylang flowers	A method of harvesting facilitated by pruning.
Niger	Euphorbia	A method of "pole" cutting to raise important trees used to stabilize sand dunes and as firewood.
North Africa	Date Palm	A process for inducing hydric stress by encircling trees in low trenches of salt to encourage early fruit formation.
North Africa	Olive trees	A process for propagation in sandy soil using cuttings with broad bean seeds, barley seeds, and pine cuttings.

Country/Region to:	Crop:	Innovation:
Zaire	Banana	A method of selecting suckers to maximize plant fruit productivity.
Zaire	Guava	A method of mound layering has tree cut to base and coppices buried in soil for months until transplanted as new trees.
Zaire	Paw-paw	A method of fixing the sex of plants through seed selection.
Zaire	Sweet Potato	A method of selecting suckers to maximize plant fruit productivity.
Congo/ Indonesia	Manihot	A method of positioning cuttings to determine fruit size. Some Manihot have "memory" that farmers must take into consideration.
Congo/ Indonesia	Terminalia	A process of top-pruning to stimulate lateral growth creating much-needed shade trees.
Indonesia/ Malaysia/ Guinea	Kopak tree, Angsana, Manihot	A process by which giant "pole" cuttings are used to form living hedges and shade on plantations or to protect family gardens.
Indonesia/ Reunion	Difficult to propagate woods	A process to propagate difficult wood cuttings by placing them close to banana plants.
Burma	Sugar palm	A method of planting to produce male or female palms as required.
Burma/India/ Indonesia	Sugar palm	A complex method of pruning and training inflorescence causing trees to increase sap yield.
China	Litchi	A method for storage in clay vases with a mix of litchis and Graminaea leaves in order to slow ripening and preserve fruit.
China	Paulownia, Kaki	A process for propagation via isolated root truncheons (Paulownia is a shade tree used in Chinese farming systems).
Gilbert & Ellice Islands	Dasheen (genus Cyrtosperma)	A method of cultivation using sand dunes between ocean and lagoon, fencing and water lentils.
Indonesia	Aubergine	A process of grafting to wild species of solanum to withstand hot and humid conditions.

Country/Region to...	Crop:	Innovation:
Indonesia	Cinnamon	A method of mound-layering of similar style used with cinnamon trees.
Indonesia	Coffee/ Durian	A process known as the "Pankas System" prunes and fixes branches to earth where branches crawl along the ground.
Indonesia	Cucumber	A process of grafting to Labu air-vine to double fruit size.
Indonesia	Damar	A method of layering ends irregular fruiting cycle and increases productivity.
Indonesia	Damar tree	A process used by Lampung (Sumatra) villagers involving unique tree nurseries and growth inhibitors and storage of young seedlings (Damar resin is exported for paints to Japan and Europe).
Indonesia	Durian	A method of gashing to stimulate fructification.
Indonesia	Jackfruit	A method of applying large bags over fruit to fend off rats and attract ants that deter other bugs.
Indonesia	Jengkok, Langsat	A process to propagate legume trees by root suckers.
Indonesia	Langsat	A method of air-layering to reduce fruiting from 10-15 years to 1-5 years.
Indonesia	Manihot	A method of grafting arborescent manihot onto manihot tubers to give ten-fold yield increase ("Mukibat" system).
Indonesia	Rice	A method of employing Azolla (floating fern) as green manure to fix nitrogen, suppress weeds, reduce mosquito reproduction (in water) and increase rice yields from 10 to 40%.
Indonesia	Tropical fruits, Tea	A process for top-grafting old trees to replace poor producers with improved stock.
Indonesia/ Thailand	Tropical Fruit	A process for grafting of young trees taking a bud from crown of older tree and grafting onto seedling to reduce time it takes Durian to reach sexual maturity (from 30 years to 4).

Country/Region to:	Crop:	Innovation:
India/Pakistan	Mango/ Lemon	A method of increasing water stress by cutting irrigation to encourage early flowering.
Malaysia	Starfruit	A method of tree-bending (daily) when young, to facilitate harvesting and to control fruit quality (plastic bags).
Malaysia/ Indonesia	Jackfruit, etc.	A process for pruning to increase flowering regularity and (sometimes) inflorescence on trunk, significantly increasing productivity.
Malaysia/ Indonesia	Rubber	A method of farmer-induced abrasions and gashes on Hevea to increase latex production.
Malaysia/ Thailand	Oilpalm	A process for pollinating oilpalm where normal pollinators are not readily available by using rotted palm leaves and imported larvae (used also on Phuket Island, Thailand).
New Caledonia	Yam	A method of cultivation using moulds and humus, yielding unique shapes and lengths of 3 meters (competitions have stimulated local breeding).
Philippines	Jackfruit	A process to prevent attack from insects and rats, seed is planted at bottom of bamboo tube and Jackfruit actually matures safely underground. Farmers locate fruit by its smell.
Philippines	Mango	A process for smoking-out mangoes, accelerating flowering.
Southeast Asia	Tropical fruits	A process for grafting for early flower ing — technique for plants normally difficult to graft.
Southeast Asia	Tropical fruits	A method of ringing either to stimulate vegetative growth or encourage photosynthesis by-products.
Southeast Asia	Tropical fruits	Fusion of seedlings of same age to speed flowering, increase vigour.
Vietnam	Citrus	A method using offal on trees to attract red ants and using string to connect trees to allow ants to move about, warding off butterflies and bugs that would harm the fruit.

Country/Region to:	Crop:	Innovation:
Vietnam	Lucuma	A method of tree pruning with branches arched and fixed to the ground to shade fruit and protect from predators.
Vietnam	Mango	A method for pruning flowers used to prevent premature fruit dropping.
Vietnam	Rice	A method of sowing several varieties simultaneously to reduce fragility and accelerate growth.
Brazil/ Congo	Manihot	A process in which cuttings are laid horizontally in trenches and buried in soil to ward off insects and disease.
Costa Rica	Erythrina, Pochote	Chorotega people use method of fast-growing shade to fend off weeds, provide livestock shade, and pasture fencing.
Ecuador	Paw-paw	A method of "pole" cutting for fencing and shade achieves 100% success using traditional strategies.
Guadaloupe	Coconut	A method of applying iron shanks or mails in base of tree to encourage fructification.
Haiti	Breadfruit	A process for propagation via root cuttings laid in original positions until sprouting (about 2 months).
Haiti	Pigeon Pea	A method of sexual reproduction by planting in holes with maize seeds.
Haiti	Sweet Potato	A method of propagation through cuttings involving heaping and storage until wounds heal.
Nicaragua	Grape	A method of slanted planting after one-day water submersion to strengthen root system when transplanted.