BIODIVERSITY
IN
SUSTAINABLE AGRICULTURAL INTENSIFICATION

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Introduction

How agriculture can be intensified while enhancing biodiversity is the critical question that society must address. The growing population and rising incomes are increasing the demand for agricultural products. Meeting this demand without affecting biodiversity is therefore a major challenge.This paper seeks to identify some of the critical dimensions to this issue, to review the conflict and complementarities and to attempt to identify practices, policies and the institutions that may help to achieve win-win situations.

Agricultural intensification does not automatically trigger greater harm to the environment. On the contrary, it can save and enhance biodiversity. Benign policies and practices that enhance agricultural productivity while conserving biodiversity hold the key for sustainable development.

Biodiversity embraces all different forms of life and has three main dimensions: the genetic variation within the species and population, the number of species, and habitat preservation[1]. The significance of variation within a species is less widely appreciated but is critical particularly for agriculture. The continued productivity of existing crops and livestock hinges in large part on harnessing the genetic variation found within each species.

The second dimension of biodiversity is an index of species richness or the numbers of distinct plants and animals in a given environment. Thus tropical rainforests are especially rich in species and their fate has major implications for many crops important for subsistence and cash income in the tropics and subtropics. Biologically speaking, biodiversity reflects not only the bounty of nature but the process of evolution itself.

Agricultural biodiversity or agrobiodiversity, as it is sometimes called, potentially includes all the aspects of diversity in nature that are connected to agriculture. Agrobiodiversity allows the farming systems to have genetic diversity to evolove, and to cope with the vagaries of nature; it also helps to control pests and diseases, enrich the soil, and recharge the ground water while meeting our food needs. It is thus the fundamental basis of sustainability in nature.

Although it is conceptually useful to differentiate agrobiodiversity from the larger array of species and habitats, it is worth emphasizing that the boundaries between biodiversity and agrobiodiversity are not clear-cut. Agrobiodiversity is a subset of biodiversity; it is that portion which is supporting agricultural endeavours in cultural habitats. All of biodiversity is potentially of use to agriculture; and mastering it is a matter of technology shifts. Agriculture is highly dynamic, and the interface between domesticated plants and

[1] Srivastava, J.P., N.J. Smith, and D.A. Forno.1996. Biodiversity and Agriculture: Implications for Conservation and Development. World Bank Technical Paper 321. Washington, D.C.

animals and wild species is constantly evolving.The advent of biotechnology has brought with it the ability to identify, isolate and transfer genes to and from unrelated organisms. Consequently, sexual barriers between species have become irrelevant. The traditional means of breeding are being complemented by genetic engineering methods that reduce time, effort, and errors.

Agriculture has a direct stake in the safeguarding of wider biodiversity and making biodiversity work for humanity and nature. Wild species are essential for agricultural improvement because they are the sources of new economic plants and animals, and provide important services such as pollination and pest control[2]. Agrobiodiversity, thus encompasses all the possible ways that natural resources can contribute to meeting human needs for food while maintaining the biological balance.

Biodiversity's Link to Agriculture

Biodiversity furnishes a constant source of natural resources to improve agriculture. It provides new genetic material to improve crops and livestock, maintains ecological balance and provides an umbrella for sustainability. Continuous changes in cropping paterns can enrich the biodiversity of managed landscapes and produce higher incomes for rural producers and urban folk who process and market agricultural goods. The diversification of farming systems increases the options of farmers and reduces risk[3]. Most farms in the tropics contain both indigenous and exotic crops, and the relative mix changes over time in response to shifts in environmental and market conditions.

Existing crops must be constantly upgraded to combat emerging pests and disease problems, and to adapt to shifting market conditions. Breeders are continuously scouring "genepools" for desirable genetic traits to make crops more inherently productive, thereby reducing dependence on purchased agrochemicals[4]. The selective manipulation of genes from within the species pool represents the most common way biodiversity is used for crop improvement.

Non- food crops including medicinal plants are an important component of biodiversity and play a significant role in the maintenance of natural ecosystems. Traditionally, medicinal plants have been considered solely for their medicinal properties and have been collected and used from the forest resources. However, in recent times, they are becoming a part of agriculture and also an important component in conservation of biodiversity.

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[2] Srivastava,J.P., N.J. Smith, and D.A. Forno. 1996. Agriculture as Friend and Foe of Biodiversity. In: Biodiversity and Agricultural Intensification, Partners for Development and Conservation. ESD Studies and Monographs Series No. 11. The World Bank, Washington, D.C.

[3] Guillet, D. 1983. Toward a Cultural Ecology of Mountains: the Central Andes and the Himalayas Compared. Current Anthropology 24(5): 561-574.

[4] Chang, T.T.1984. Conservation of Rice Genetic Resources: Luxury or Necessity? Science 224:251-256.

Certain microorganisms, part of the broader biodiversity picture, are also vital for the long-term productivity of agriculture[5]. The development of sustainable agricultural productivity will depend increasingly on the maintenance of biodiversity among invertebrates and microorganisms. Spurred on by the contamination of water supplies with nutrients from fertilizer applications, and the need to reduce the cost of fertilizers to farmers, scientists are working with a number of organisms to rationalize fertilizer and pesticide use.

Insects, normally thought of as pests, can also be a farmer's friend. Integrated pest management (IPM) can reduce dependence on pesticides since it involves a mix of agronomic practices, and biocontrol agents, to check pests. IPM is not new; various predators and parasites combined with crop rotation and mixed cropping have historically helped reduce insect pest problems in farmer's fields.

With the advent of IPM technologies, some 500 insect species have been deployed worldwide to control crop pests, with a further 100 insects released to check weeds. The success rate of such efforts has ranged from 30 to 40 percent[6]. While not matching the dramatic impact of pollen insecticides, biocontrol agents typically produce more long-lasting results with no collateral damage to the environment. IPM incorporates biodiversity, and can reduce operating costs.

The functioning and sustainability of agricultural systems depend greatly on biological diversity. A study points out that more diverse plant communities use and retain nutrients more efficiently, thereby attaining greater productivity and reducing nutrient leaching losses from the ecosystems[7]. Every single species that exists in an agroecosystem has some intrinsic value. Elimination or addition of one species can have profound effect on ecosystem.

It is of special concern to incorporate greater biodiversity within agricultural production systems. New approaches to agricultural research and development are being tried out in various places around the world, and virtually all of them emphasize a much better harnessing and management of biological processes than has prevailed in the past. We also need to change the policies, wherever required, to support this and to make every stakeholder an equal partner in this transition process.

It will be vital to create awareness among the ultimate managers of biodiversity, the farmers and livestock raisers, about the importance and value of biodiversity, and to

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[5] Hawksworth, D.L.,Ed., 1991. The Biodiversity of Microorganisms and Invertebrates: Its Role in Sustainable Agriculture, Wallingford: C.A.B. International.

[6] Waage, J.K., 1991. Biodiversity as Resources for Biological Control. In: The biodiversity of Microorganosms and Invertebrates: Its Role in Sustainable Agriculture, D.L. Hawsworth, Ed., Wallingford: C.A.B. International.

[7] Tilman, D., D. Wedin, and J. Knops. 1996. Productivity and Sustainability Influenced by Biodiversity in Grassland Ecosystems. Nature 379: 718-720.

provide them with necessary tools to manage it sustainably so as to meet their needs while conserving it for the future generations.
To address these issues the following questions should be looked into:

- What impact do agricultural development activities have on biodiversity, both in managed and natural habitats?
- How do we develop sustainable agriculture as an integral part of biodiversity conservation?
- What policies, institutions, incentives, and technologies will reduce the losses of biodiversity while promoting agricultural growth?
- What are the trade offs between agriculture development objectives and biodiversity conservation?

Sustainable development aims at achieving economic, social, and ecological goals. In our pursuit of achieving food security and increased productivity through agricultural activities, we must simultaneously ensure social equity and ecological integrity. These are the goals endorsed by the Biodiversity Convention and fall within the framework of sustainable development.

Impact of Agriculture on Biodiversity

Biodiversity has allowed farming systems to evolve since the dawn of agriculture development. Agriculture production systems have historically maintained high levels of species diversity as well as a rich assortment of crop varieties. However, in recent times, the population explosion has led to unrestricted expansion into forests and marginal lands; this, combined with overgrazing, urban and industrial growth, monocropping, and changes in crop rotation patterns and pest management strategies have contributed to the erosion of biodiversity both within and outside agricultural landscapes[8].

Modern agricultural practices have involved the loss of genetic diversity of crop and livestock varieties and decline of diversity in agrosystems. Of the roughly 7000 plant species that are cultivated and gathered for food, only a handful dominate food production worldwide. A total of 30 crops account for 95 percent of energy and vegetable protein consumption of humanity[9]. The loss of biodiversity due to homogenization has made the crops susceptible to diseases and pests, and vulnerable to climatic stresses which often lead to serious economic loss.

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[8] Mainstreaming Biodiversity in Agricultural Development, Toward Good Practice. (Draft), 1996. Environmentally Sustainable Development, The World Bank, Washington, D.C.
[9] FAO, 1996. The State of World's Plant Genetic Resources for Food and Agriculture: Prepared for the International Technical Conference on Plant Genetic Resource, Leipzig, Germany. June, 1996. Food and Agriculture Organization, Rome.

Under the modern system, intercropping and polycultural practices have dissappeared making way for industrial agricultural practices involving the indiscriminate use of agrochemicals and homogeneous lines. This has resulted in an enormous loss of agroecosystem diversity and the related loss of diversity in available food, leading to nutritional imbalance among the rural people.

Excessive use of agrochemicals has also caused the loss of insect diversity.This disruption in agroecosystem balance has been the reason behind major insect and pest outbreaks.
Use of agrochemicals have also brought about irreversible changes in soil microorganisms and depleted the soil of its natural nutrients. The "off-site" impacts of the agrochemicals have been alarming, causing air, water, soil, and atmospheric pollution, affecting the entire ecosystem.

Biodiversity and Sustainable Agriculture

The traditional systems of agriculture mimic nature; it is the best way to conserve nature. However, in our constant effort to raise agricultural production, we can not rely solely on traditional practices and hence, there is need for striking a balance between the modern technology and the traditional practices.

The linkages between agriculture and biodiversity have changed over time. Global agricultural production and productivity have substantially increased from both intensification as well as extensification processes and also from a combination of improved varieties and agronomic practices. However, conventional forecasts for the coming decades indicate that the world food production must at least double by 2025 to meet the rising demand for food. There is not only growing concern over the agriculture to meet this demand but also over the long-term sustainability of growth that has already occurred. Current patterns of agricultural development have substantial external costs to society at both national and global levels; with shrinking areas available for agricultural expansion, increasing world food production must come from sustainable intensification.

To facilitate this process of sustainable intensification of agriculture and enhancement of biodiversity, it will be necessary to bring changes in production systems and create supportive policy environment by eliminating inappropriate subsidies; it will be important to create awareness among local people about the value of biodiversity and protect their rights to the genetic resources. The new paradigm of agricultural research should complement this effort and provide support for better management of biological resources.

Sustainable intensification will thus involve greater reliance on biological methods for control of diseases and pests, for maintaining soil nutrient balance etc. The incorporation of traditional principles is very crucial and can be done through local peoples' participation, using their age-old wisdom to complement modern development. The

involvment of farmers in research and planning is also important to develop agroecological methods that suit local conditions.

An important step towards achieving sustainability in agriculture in coordination with nature will be to re-introduce crop rotation, inter-cropping, covercrops, biofertilizers like legumes, bacterial cultures, and integrated pest management techniques. These agroecological practices to intensify agriculture will reduce pressure on natural habitats thereby saving biodiversity.

Another important aspect of saving biodiversity while promoting sustainability is through revegetation of agricultural areas. This means planting native trees in "remnant" habitat areas or forest margins[10]. This integration helps restoring the natural habitat where traditionally agriculture thrives best and also establish semiprotected areas of revegetation to enable people to use resources in a planned manner[11]

Need for Policy Changes

Agricultural development is intricately linked to biodiversity conservation; in planning for agriculture, governments need to assess the extent to which policies, institutions and investment programs have to change to accommodate the objectives of conserving biodiversity as well as the costs and benefits of such adjustments.

Many essential elements of biodiversity conservation require a sustained commitment. Policies, institutions, laws, and attitudes take a while to change; expanding human capacity, carrying out frontier research and conducting inventories take time. Still immediate action is needed. Irreplaceable genes, species, and ecosystems are disappearing at a rate unprecedented in human history and, as a result, essential development is at risk. The limited conservation resources available must be focused strategically on opportunities likely to yield the greatest conservation benefits.

Ultimately, it is the farmers themselves who will determine how much biodiversity is lost or saved; they need the information and technology to help better manage and conserve biodiversity. In some cases, they already have the necessary knowledge and biological "tools", but lack the incentive to deploy them on a wider scale. The policy environment or directives of a development project may thus be constraining the potential benefits of indigenous knowledge.

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[10] Hobbs, R., 1993. Can Revegetation Assist in the Conservation of Biodiversity in Agricultural Areas? Pacific Conservation Biology. Vol 1: 29-38.

[11] Thrupp, Lori Ann. 1996. Agriculture and Biodiversity: Conflicts, Complementarities, and Opportunities (Draft). World Resources Institute, Washington D.C.

Assessment and evaluation of Tradeoffs

Valuing the benefits of biodiversity remains intrinsically difficult. Many ecological relationships are uncertain, and it is difficult to assign value to the services that conservation efforts provide.Some of the benefits can be measured, IPM technologies, when introduced in combination with cover crops, crop rotations etc., can reduce pesticide cost by 80 percent while maintaining the same production level.However, the value of other benefits not quantifiable in terms of monetary gains can be enormous. The services these technologies provide in terms of saving agroecology, saving the soil microorganisms and helping in maintaining nutrient balance can not be measured by any conventional methods.

Towards a Strategy for Biodiversity Conservation

In 1992, the United Nations Conference on Environment and Development (UNCED), the Earth Summit, adopted Agenda 21, which represents a global consensus and political commitment to sustainable development at the highest levels of the governments. The Convention on Biological Diversity (CBD), recognized the link between biodiversity conservation and sustainable development and made some important obseravtions[12]. The most relevant of these are:

- Biodiversity conservation and management is not just an ecological concern, for many countries, sustainable utilization and conservation of biodiversity are intrinsic to socioeconomic development. Especially for the rural poor, biological resources often provide the single most important contribution to their livelihoods and welfare in the form of food supplies , medicines, shelter, income, employment, and cultural integrity.
- Successful biodiversity conservation depends on sound policies (pricing, taxation, land tenure) and effective institutional and social arrangements (laws, regulations and roles of the state, private sector NGOs, local communities and indigenous people), provision for which often falls outside the traditional conservation domain of resource management agencies and protected area administrations and systems.

Successful action to conserve biodiversity must address the full range of causes of its current loss and embrace the opportunities that genes, species, and ecosystems provide for sustainable development[13]. The goal of biodiversity conservation, supporting sustainable development by protecting and using biological resources in ways that do not diminish

[12] Mainstreaming Biodiversity in Development: A World Bank Assistance Strategy for Implementing the Convention on Biological Diversity. 1995. Environment Department Paper No. 029.

[13] Global Biodiversity Strategy, A Policy-Makers' Guide.World Resources Institute (WRI),The World Conservation Union (IUCN), and United Nations Environment Programme (UNEP), in Consultation with Food na Agriculture Organization (FAO), and United Nations Education, Scientific,and Cultural Organization (UNESCO).

world's variety of genes and species or destroy ecosystem, thus can be achieved through:

- Development of national and international policy framework that foster sustainable use of biological resources and maintenance of biological diversity;
- Creation of conditions and incentives for effective conservation by local communities;
- Strengthening tools of conservation of biodiversity;
- Strengthening human capacity and awareness for conserving biodiversity;
- International cooperation.

The above objectives can be successfully fulfilled by mainstreaming biodiversity conservation a practice at every level. The government machineries at state and national levels, developmental institutions, banks, national, international research organizations should give priority to biodiversity conservation in their agenda. It will also be important to involve all the stakeholders, the farmers, the livestock raisers in the design and implementation of the developmental programs.

Constraints to adopting more biodiversity friendly agriculture can be traced to failures of the policy and regulatory environment, institutions, and markets. Guidelines for mainstreaming biodiversity, therefore, should focus on such recommendations as reducing subsidies for inputs that destroy biodiversity, realigning priorities at institutional level to develop and promote benign technologies that can sustain or even raise yields, and taking advantage of emerging market opportunities to diversify agriculture.

Addressing the key issues

Strengthening Information Base

The initiative to mainstream biodiversity conservation should start with gathering and evaluating information on the status and trends of the nation's biodiversity and biological resources, laws, policies, organizations, programs, budgets, and human capacity, identifying gaps between desired and current situations, reviewing options to close the gaps, selecting preliminary goals and objectives, and estimating costs, benefits and unmet needs.

These data should be collected from all possible sources of civil society including government, NGOs, research / academics, private sector, and all the stakeholders to strengthen the country knowledge base and have a holistic view of the existing status of biodiversity. This information base will put the country on a strong footing and form the basis for policy making..This will also help to expand the sphere of decision making and

everyone will become a direct or indirect participant and will work towards a common objective with a holistic approach.

Recognition and Diagnosis of Threats to Biodiversity

Application of databases and tools like Rapid Assessment of Biological Resources (BIORAP), can help in providing a baseline information on biological resource and identify the extent of loss. National Environment Action Plans (NEAPs) and Biodiversity Strategies Action Plans (BSAPs) prepared by the developing countries are also indicative of the threat to biodiversity and provide a framework to integrate environmental concerns into economic and social developmental efforts. However, NEAPs and BSAPs have yet to make a significant impact on development planning, either at the macroeconomic or sectoral policy level or as a contribution to reorienting public expenditures. Identifying priority problems should, therefore, include criteria like economic productivity, ecological functions, and ecosystem integrity. The environmental strategies should be based on consultations with those who are responsible for environmental problems, those who are adversely affected , those who control policy instruments for solving problems, and those who have the relevant data and technical expertise.

Improving the Policy Environment

Biodiversity planning is an open ended process that develops continuously as further information and experience is gained. The process is iterative, with the same steps repeated round after round. It is adaptive because participants learn from past experiences about shifts in nature and society. They also learn about the institutional, scientific, legal, and policy obstacles where changes are warranted. Among the most important factors for facilitating biodiversity planning and action are solid political will and commitment by the highest levels of governments.

A wide range of national policies, laws, and regulations can create "perverse" incentives that discourage conservation. For example, the conversion of natural areas and loss of biodiversity has often been accelerated by economic policies that encourage production for export markets, promote population resettlement, or open up remote areas to road construction and logging. While the appropriate policies provide basis for national development and for meeting the economic needs for people, inappropriate policies can result in unsustainable and inefficient natural resource use, and contribute unnecessarily to the loss of biologically significant natural habitats and species.

Land Tenure Policies: Changing property rights and land use laws can have a significant impact on biological diversity. For example, the nationalization of forest lands in most countries has often led to destruction of forest lands by local people who no longer have the legal responsibility of managing them. In the Philippines, Indonesia, and Thailand, the lack of tenural security has acted as a disincentive to land improvements and encouraged expansion of agriculture onto upland watersheds and marginal lands.

Quality Pricing: If farmers receive premium prices for unusual but attractive varieties of crops, they will be encouraged to grow them. A price grading system that rewards farmers for not only growing "clean" produce, but for offering a diverse array of fruit and leaf types will help generate heterogeneity on agricultural landscapes.

Reduction of Farming Subsidies: Agricultural subsidies often trigger biodiversity loss. Such losses occur because farmers may use more purchased inputs, such as environmentally damaging pesticides and fertilizers or irrigation water, than they would if they had to pay market prices. A highly subsidized crop also tempt farmers to clear land that would otherwise be left in a relatively undisturbed state.

Intensification of Agriculture: Intensification of agriculture has often been discouraged by policies that discriminate heavily against the agriculture sector. It is now well documented that these policies have slowed down agricultural and economic growth substantially. Policy reforms that remove impediments to intensification can help increasing agricultural production and also ease pressure on the remaining habitats.

Credit for Traditional Varieties: Typically, credit is available for "approved" varieties that are certified by the national seed boards. The traditional varieties are rarely included in the trials for certification even if their performances are better than the improved varieties. Likewise, livestock raising is dominated by only a handful of breeds causing an erosion of traditional breeds of livestock. The credit system and incentives can be structured in such a way so as to encourage people to raise traditional breeds that might otherwise disappear.

Integrated Conservation and Development

Meeting human needs: Integrated Conservation and Development Projects(ICDPs) are one recent attempt to link the conservation of biological diversity in protected areas with local social and economic development. Most ICDPs try to stabilize land use outside the protected areas and increase local incomes, with ultimate objective of reducing pressure for further exploitation of natural resources within the protected area.

Encouraging Women to Protect Biodiversity: Women in developing countries often develop extensive knowledge about forest products and medicinal and other local plants as they make economic use of a much wider range of products than men, and have greater interest in sustaining the diversity of biological resources. Recognizing this linkage, the Asia Pacific Regional Assembly on "Women and the Environment: Partners of Life" in Thailand (March, 1991), called for strategies that promote women's participation in planning , implementation, evaluation, and benefit sharing.

Using Productive Areas for Biodiversity Protection: From biological point of view protected areas that become isolated "islands" amid agricultural land and human settlements invariably result in a progressive erosion of genetic diversity. This happens because human activities set up barriers against normal mixing and outbreeding of species populations in the protected area. However, multiple-use of agriculture, or

improved management of watersheds and forests around protected areas, can offer opportunities for extending the range of biodiversity protection while achieving economic objectives[14].

*Integrated Agriculture: A*grobiodiversity can be protected successfully by introducing integrated agriculture. By combining different kinds of crops, altering cropping patterns, and introducing crop rotations, and mixed cultivation by bringing tree crops under the agricultural cropping system soil fertility can be enhanced and disease and pest infestation can be reduced; this helps the farmer in risk aversion. The objective of sustainability can also be achieved through integration of multiple activities, such as combining agriculture, livestock, fisheries etc. where each activity complements the other and help conserve biodiversity.

Balanced Conservation Strategy

Conservation and utilization of crop genetic diversity is a major concern around the world. The indigenous systems may be far more open and dynamic than is commonly imagined. The relevance of the models that would 'freeze the genetic landscape' under the supposition that conservation and development are compatible are often questioned. At a slow rate of introduction, foreign germplasm tends to be a source of phenotypic diversity rather than a cause of genetic erosion.

It is often argued whether the plant and animal genetic resources should be maintained for conservation in places where they occur naturally ("in situ"), or they should be safe-deposited in the field genebanks or seedbanks ("ex situ").

While measures to improve the usefulness of "ex situ" collections of plant and animal genetic resources are warranted, considerable attention is now being focused on ways to promote "in situ" conservation. The approaches to "in situ" conservation emphasize safeguarding the wild populations or near relatives of crops and livestocks in the existing parks and reserves where they belong, creating world heritage sites for genes for agriculture development, protecting sacred sites for agrobiodiversity where there are preponderance of wild populations of crops or related species.

The FAO organized conference on Plant Genetic Resources, in Leipzig, Germany in June 1996, recommended a strong need for more "in situ" conservation in places where most of the genetic resources are found. Emphasis was also given on "ex situ" conservation: gene banks, seedbanks, and on farmers' participation in conservation exercises.

Unfortunately, "in situ" conservation is expensive and requires a lot of land area. These are limiting factors in the context of developing countries, where it is most needed. External assistance may become available for a short period but these efforts require

[14] Pimental, David et al, 1992. Conserving Biological Diversity in Agricultural/Forestry Systems. Bioscience. Vol 42(5).

support on a sustained basis. It will, therefore, be important to devise a biologically sound strategy that encompasses both "ex situ" and "in situ" conservation, so that they can operate synergistically.

Financial Resource Mobilization for Biodiversity Conservation

Domestic Resource Mobilization: Most countries rely on internal resource mobilization for at least a part of their conservation expenditures. In the case of countries with large forest estates or protected systems, these expenditures may be considerably high. In such cases natural resources taxes or levies on development or private sector use can provide promising avenues for generating financial support.

Development Linkages: Development projects frequently modify natural environments and may be opposed by the concerned environmentalists, but such projects can also be used to obtain leverage and financial resources for biodiversity protection.

Intellectual property rights

The issues concerning Intellectual Property Rights (IPR) policies have generated great debate and discussion.The legal options influencing IPR for plant genetic resources (PGR) and innovations are different in different countries[15]. In 1987 , the Commission on Plant Genetic Resources (CPGR) accepted protection for breeders in exchange for recognition of farmers' rights. The International Undertaking on Plant Genetic Resources was also formed at this time as an agreement to recognize local communities and farmers' contributions and interests in developing and conserving PGR. In 1993, the Convention on Biological Diversity (CBD), however, supported national sovereignty and the rights of the countries to benefit from their natural resources[16].

Public institutions are generally concerned about how laws affect their research programs, and the availability and access to resources, while companies are concerned about protection of innovations to recoup their research investments and to control profit from the products. Groups of civil society, particularly the farmers, are interested in ensuring that common people have equitable access to and benefit from IPR and that farmers' rights are recognized. Many countries considered that farmers' right should be considered as being complementary, and not opposed to plant breeders' rights.

Fiscal and Regulatory Policies

Some of the major constraints to farmers adopting more "environmentally friendly" agricultural practices can be traced to distortions in the fiscal and regulatory environment in which they operate. Some of the underlying causes that are driving biodiversity loss in an agricultural setting can be attributed to distortions in fiscal policies. A wide assortment of credit and tax regulations either prevent farmers from using greater biodiversity in their operations or accelerate destruction of natural habitats.

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[15] Jondle, R., 1993. Legal Protection for Plant Intellectual Property, International Crop Science I. Madison: Crop Science Society of America.

[16] Convention on Biodiversity, 1993. United Nations.

Considerable efforts have been made in recent years to find mechanisms that will provide farmers with greater benefits from biodiversity. These include efforts to revise property rights and to develop new income opportunities for local communities from the royalties on the genetic materials collected the areas they protect. Some of the policies that need consideration in this regard are:

- Environmental Taxes: In the background of the potential for damage that chemical pesticides cause, there is justification not only on removing subsidies but also on imposing taxes on such inputs. Environment (Green) taxes can also substitute for the missing markets for the damages and lead the farmers to internalize these costs in their decision making.
- Property Rights: Property rights would ensure that biodiversity is used appropriately. Owners would demand compensation from the beneficiaries and protect their properties from damages.
- Regulation by Local Communities: Local communities can be effective resource managers if they have the ability to enforce rules and the incentives to do so.
- Subsidies: The benefits of biodiversity are often public goods; there is, therefore, a logical case for giving subsidies to those who bear the costs of providing them. Conservation trust funds are an innovative mechanism through which the global community may compensate the local people for conserving biological resources.
- Decentralization: Decentralization of authority and responsibility plays an important role in safeguarding biodiversity at the local level. However, decentralization to the level of state governments (India), or parastatal organizations (Kenya), is not enough. Participation by local communities is vital. Only if they are empowered to significantly influence and benefit from a conservation effort will they cooperate to make it a success[17].

Agricultural Research and Development

Agricultural research plays a crucial role in conservation of biodiversity. So far, it has concentrated on maximizing output rather than considering the production systems as a whole, tending to ignore local agrobiodiversity, and may even have caused its destruction to some extent.

Agrobiodiversity can be enhanced along two dimensions: by increasing genetic diversity within species and by deploying a wider range of crops. Agricultural research and development programs tend to narrow the genetic base of the major crops. In many developing countries, when modern varieties are imported, they donot hold up for long because of the absence of adequate breeding programs to develop modern varieties better adapted to local conditions.

[17] Decentralization and Biodiversity Conservation. Ed. Ernst Lutz and Julian Caldecott. A World bank Symposium.

Commodity programs focus on a handful of crops, often totally neglecting the "minor" crops. Yet some lesser known crops may hold the key to turning the food production around. Only a small fraction of the world's remaining half a million plant species have been screened for the economic potential. When priorities for crop research are being established, therefore, considerations should be given to under-utilized species so that they are not further marginalized.

New approaches to agricultural research are being tested around the world. Many of these approaches emphasize better exploitation and management of biological resources than has prevailed in the past. Instead of relying on an arsenal of potent chemicals to improve soil fertility and thwart the attacks of insects and diseases, agricultural research is increasingly turning to biological assets, including the manipulation of genes and predators of insect pests.

Realizing the need, a new agricultural research paradigm is evolving along many fronts at different rates in different parts of the world. This new vision for agricultural research adopts a holistic approach that is more sensitive to environmental concerns, while still addressing the need to boost yields and incomes of rural producers and caretakers of the land.

- In order to intensify agriculture in harmony with biodiversity and to exploit their complementarity to its fullest potential, agricultural research must emphasize the following:
- "Ecotechnologies" by blending traditional and frontier technology to achieve sustainable agricultural development while conserving biodiversity.
- Crop breeding programs to promote greater genetic and species diversity, focusing on adaptive research, breeding heterogeneous varieties of cross-pollinated crops, developing multilines which are agronomically similar but contain different genes that confers traits like disease and pest resistance etc, involving farmers in the breeding process as active partners, and developing varieties that can be grown in different farming situations rather than the current pattern of promoting super varieties over vast areas.
- Integrated Pest Management (IPM) strategies to release biocontrol agents; deploy genetically resistant cultivars and breeds; use of pesticides and herbicides judiciously; alter cropping pattern, introduce crop rotation to prevent build up of pests and diseases.
- "Eco-Friendly" farming as a transition from chemical and machinery intensive farming to knowledge intensive farming.
- Indigenous knowledge in research and development programs ; recognize the strength of ethnobotanical knowledge in identifying local varieties with greater commercial potential and explore valuable plant resources in forest and other habitats.
- Diversity of habitats within land use systems such as cereal cropping by allowing for a variety of habitats such as riparian buffer strips, shelter belts, wind breaks, strip

cropping, and wetlands; creation of niches for wildlife and micro-climates for the buffer crops.

- Recycling of organic matters by incorporating livestock and green manure in no-till or minimum -till farming and help sustain the diversity of soil microorganisms.
- Farmers' participation in research -- through conducting "on farm" demonstration trials, and involving the farmers in research from the planning stage to have demand driven research.

Evaluation of Trade- off

It is necessary to evaluate the benefits of biodiversity, because protecting them might in some instances conflict with other objectives. Similarly, activities to restore biodiversity benefits require cost-benefit analysis. But valuing the benefits of biodoversity remains intrinsically difficult. Many ecological relationships are uncertain, and it is difficult to assign value and services because many do not enter markets. But some 'common' concepts can be used to estimate the value of some of the benefits generated by biodiversity and the effects of agricultural activities upon them. When damage to biodiversity reduces agricultural productivity, the change in output also reduces benefits. When other services are affected, replacement costs can often be used; for example, the cost of treating water to replace the water filtration service provided by wetlands can be used as a measure of its benefit. Where there are threats of serious or irreversible damage, the lack of full scientific certainty should not be used as a reason to postpone cost-effective measures designed to prevent environmental degradation.

Monitoring and Evaluation

Improved information will provide sectoral planners with concrete evidence of the relationship between agriculture and biodiversity. Gathering information, therefore, becomes crucial in understanding the agriculture- biodiversity syndrome. Information is required on the extent and nature of damage to biodiversity; however, monitoring the state of biodiversity and the pressure on it is often limited. As of now, there is no monitoring in agricultural landscapes, and whatever little is there pertains to natural habitats. Attempts at evaluatopn should focus on assessing the damage and estimating the likely returns to the interventions so that scarce resources can used optimally. The state of the art techniques in this field remains poor; but some information is available to justify policy interventions and assess the nature of the required response.

The Role of The World Bank

The World Bank can play an important role in mainstreaming biodiversity concerns in agricultural investment projects while promoting sustainable agricultural practices. It can facilitate policy dialogue with the governments for the development and coordination of improved macroeconomic, sectoral and natural resource policies that promote sustainable development objectives. Given the comparative advantage and the importance of national policies in establishing an effective incentive structure for biodiversity conservation, the

Bank is trying to assist the member countries to mainstream biodiversity conservation by taking initiative to:

- integrate biodiversity conservation and sustainable use within its overall policy dialogue and country assistance strategy (CAS).
- adjust its traditional economic sector work to include biodiversity priorities and issues (possible in the context of better addressing global externalities);
- reflect biodiversity objectives in the design of individual investment projects across sectors of the economy;
- enhance environmental assessment practices;
- support the development of human resources and the institutions that are required to facilitate the mainstreaming of biodiversity; and
- adapt internal operational procedures and practices to better support the mainstreaming of biodiversity in its developmental work[18].

At the "macro" level, the Bank, through policy dialogue and country assistance strategies, is helping the member countries to bring environmental considerations into government policy making and development planning. The Bank has also assisted client countries to develop and implement biodiversity strategies and action plans in accordance with their obligations under the Convention of Biological Diversity through support for consultations, studies and technical assistance.

At the sectoral level, the Bank has taken initiative to incorporate studies and analyses on issues like natural resource management in the sectoral reviews. The bank has launched Global Overlays Program in partnership with bilateral donors and NGOs to internalize global externalities into national environmental planning and Bank's sector work. At the project level, it is including biodiversity conservation as an objective, wherever applicable. Also, in individual investment projects, environmental assessment (EA) is being fully integrated in the project cycle during project preparation.

The Bank is helping the developing countries in building capacity for biodiversity conservation by creating awareness among the policy makers and enhancing skills and the availability of "tools" to the technical staff of the government agencies. The Bank is also providing link between the concerned government agencies and the sectoral agencies responsible for agriculture, forestry, fisheries etc. The Bank has commissioned a methodology, a set of analytical tools for rapid appraisal of biological resources (BioRap) to identify priority areas for conservation and sustainable management of biodiversity.

To assist countries in developing and managing a protected area systems, the Bank would support the development and maintenance of ecologically viable, economically sustainable, and socially appropriate "biodiversity reserves" that adequately represent terrestrial and aquatic habitats and protect key and endangered ecosystems or habitats .

[18] Mainstreaming Biodiversity in Development: A World Bank Assistance Strategy for Implementing the Convention on Biological Diversity,1995. Environment Department Paper No. 029.

In order to assist countries in promoting biodiversity conservation outside reserves, the Bank is taking the initiative to develop codes of practice to protect and enhance biodiversity conservation in key areas such as agriculture, forestry, fisheries, water resources management, coastal zone management, human settlement, and infrastructure development.The Bank would support the maintenance of genetically viable reference populations of wild races and existing cultivars of important crops and potential crop species, including support for "ex situ" conservation where "in situ' measures are not feasible. The Bank would also support the creation of positive incentives for biodiversity conservation at the local level by generating sustainable alternative livelihood.

Through these efforts, the Bank has been able to make some progress in mainstreaming biodiversity conservation in environmentally sustainable development activities, of which agriculture is a key component. From 1988 to mid-1995, eighty four Bank projects in fifty-one countries addressed issues concerning biodiversity conservation[19]. An analysis of the agriculture sector portfolio revealed trend towards biodiversity-friendly prctices in agriculture development projects eventhough biodiversity conservation issues were not of prime consideration in many of these projects. It is expected that in future greater attention will be paid to biodiversity conservation and use in agricultural sector projects.

[19] Jana Sakti and Sanjiva Cooke, 1996. Biodiversity and the World Bank's Agriculture Portfolio. In Biodiversity and Agricultural Intensification, Partners for development and Conservation, ESD Studies and Monographs Series No. 11. The World Bank, Washington, D.C.