**Role of biotechnology in sustainable agriculture and rural development.**

The word “sustainable” comes from the word “sustain” which means to maintain, support, or to endure. People involved in sustainable agriculture are trying to identify and solve the problems in our current agricultural system in order to provide food and fiber in a healthy environment for people over the long term. At least for now, no one has developed a fully sustainable agriculture, and for the foreseeable future there will always be room for improvement.

**The Three Legs of Sustainability:**

Imagine a 3-legged stool **.**What happens if one of the legs breaks, or one leg is missing entirely? The whole stool falls over. The 3-legged stool has become a metaphor for the need to consider the economic, environmental, and social impacts of agriculture (or any of our actions). If our agricultural system has unacceptable impacts in any one of these spheres, it can't support producers and contribute to the community over the long term.

In order to be sustainable, three areas must be addressed by our agriculture, food, and natural resource systems. These three areas are **economics, environment,**and **community**. A sustainable agriculture must provide a fair and reasonably secure living for farm families. It should minimize harm to the natural environment. It should maintain basic natural resources such as healthy soil, clean water, and clean air. And it should support viable rural communities and fair treatment of all people involved in the food system, from farm workers to consumers.

The 1990 Farm Bill defines sustainable agriculture as:

“an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

* satisfy human food and fiber needs
* enhance environmental quality and the natural resource base upon which the agricultural economy depends
* make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
* sustain the economic viability of farm operations
* enhance the quality of life for farmers and society as a whole.”

Let's take a look at each individual “leg” of the sustainability stool.

*Sustainable agriculture is “economically sustainable.”*Agriculture should provide a secure living to farm families and others employed in food production and processing. An economically sustainable approach also provides access to good food for all people.

*Sustainable agriculture is “environmentally sound.”*It preserves the quality of basic natural resources that the farms, businesses and the surrounding environment rely on, including soil, water, and air. Agriculture affects natural resources. Cooperating with natural resource systems instead of trying to overpower them can offer benefits to food production as well as the natural environment .

*Sustainable agriculture is “good for families and communities.”*It promotes opportunities and cooperative relationships for family and community members. For example, a local food marketing system called community supported agriculture (CSA) offers opportunities for people to get into farming without major capital investment; provides work for family members, including children, on the farm; and creates direct partnerships with consumers in the community.

**Goals versus Practices**

Profitable economics, healthy environment, and vital communities are all *goals.*They are what we are trying to achieve. *Practices*are actions we take to achieve those goals. Why don't we define sustainable agriculture in terms of practices? There are two important reasons: First, we expect that our knowledge will increase in the future, so practices used now may not be considered the best practices ten years from now. Second, the effect of a practice can vary enormously depending on how and where it is performed. For example, plowing on a steep hillside is unsustainable because it causes too much soil erosion. However, occasional plowing on level ground can be a sustainable tool for some cropping systems.

 In order to attain our goals, we need to take certain actions, that is, follow certain practices. So one of the things we'll explore in the next few days are examples of sustainable practices, such as crop rotation, riparian buffer strips, rotational grazing, and direct marketing. Keep in mind, though, that these are not all the possible practices and if they don't help us achieve our goals, they are not sustainable, no matter what the practice.

**The Organic Example**

For many people, sustainable agriculture is closely identified with organic agriculture. Unlike sustainable agriculture, though, organic agriculture is officially defined by *practices*rather than *goals*.

In the United States , the practices that are **required**and the practices that are **prohibited**in organic agriculture have been set forth in federal law since 2001. Anyone can use these practices in their garden or field, but for products to be labeled and sold as “organic” they must be certified by an independent third-party certifier. In a nutshell, organic farmers must:

* rotate crops to maintain soil quality and manage pests,  
  •  keep records of their operation that will be examined by the certifier,  
  •  minimize use of off-farm inputs,   
  •  refrain from using synthetic fertilizers or pesticides, and   
  •  refrain from using genetically modified organisms.

An organic processor must:

* keep organic products separate from non-certified products, and
* keep synthetic pesticides, preservatives, and other unapproved substances away from organic products.

Visit the [US organic standards](http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateA&navID=NOPHomelinkNOPOrganicStandards&rightNav1=NOPHomelinkNOPOrganicStandards&topNav=&leftNav=&page=NOPNationalOrganicProgramHome&resultType=&acct=nop) to get a sense of some of the complexity of the requirements and the questions surrounding this relatively new program. For additional information, see the [National Organic Program's web page](http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateA&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPNationalOrganicProgramHome&acct=nop).

**Is organic agriculture sustainable?**

Many farmers and consumers feel that organic agriculture is sustainable. On the whole, organic practices do a good job of protecting the natural environment and may be better for the health of both producers and consumers. Farmers also like the fact that organic products often bring higher prices in the marketplace, which means they contribute to economic sustainability.

Other farmers and consumers note that organic agriculture does not really address economic and social sustainability. When most organic producers and processers were small-scale idealists, organic agriculture may also have addressed social and economic needs in rural communities. However, as the organic market has grown, the organic food system has come to look more like the conventional food system, with large-scale producers and processors and shrinking margins for farmers.

Suggested discussion or essay question: Which is better – a general goal-oriented definition like that for sustainable agriculture or a more specific practice-based definition like that for organic agriculture? What are the advantages and disadvantages of each? Provide specific examples.

Role biotechnology provides estimated and strategic approach to provide combined efforts in protecting three major legs of sustainable agriculture, It could not just be a practice, it could a combined strategic effort in solving issues emerging from social demands, environmental disturbance and climatic changes.

Biotechnology is defined as of the Convention on Biological Diversity as any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific uses. Agricultural biotechnology is a collection of scientific techniques, including genetic engineering, that are used to modify and improve plants, animals and micro-organisms for human benefit. It is not a substitute for conventional plant and animal breeding but can be a powerful complement. The present report explores what roles biotechnology may play in contributing to sustainable agriculture and rural development, with particular concerns for biosafety and biodiversity. It focuses on several major policy issues, presenting biological diversity as a source of raw product for crop and animal improvement, including the use of biotechnology. And it considers bio- safety as a major domain for addressing the impact of biotechnologies on health and the environment.

**Potential of biotechnology for sustainable agriculture and rural development**

1. Agricultural biotechnologies have major potential for facilitating and promoting sustainable agriculture and rural development. They could also generate environmental benefits, especially where renewable genetic inputs can be effectively used to substitute for dependency on externally provided agrochemical inputs. The fact that genes or genotypes (e.g., varieties, breeds) can constitute locally renewable resources is of profound significance to the further development of sustainable agriculture and rural development. However, the power of modern biotechnologies to generate useful genotypes has not yet been harnessed for poorer farmers.
2. Nevertheless, the extent to which modern biotechnology will contribute to the achievement of food security for all is still an open question.1Science alone is unlikely to provide a complete solution to the problems of rural development. There are many processes, factors and socio-economic structures underlying poverty in rural areas, such as lack of access to land and other productive resources, low purchasing power, political powerlessness, fragile environments and distance from markets. Agricultural (or indeed plant biotechnology) research is but one factor which could impact on rural poverty; it is not a panacea for sustainable agriculture and rural development.
3. Comparative reviews of the state of agricultural biotechnologies in some developing countries have been carried out by the International Service for National Agricultural Research — Intermediary Biotechnology Service, a Consultative Group on International Agricultural Research (CGIAR) centre, and the Organisation for Economic Cooperation and Development (OECD), which concluded that the majority of developing countries have limited practical access to the tools and germplasm necessary to apply more sophisticated biotechnology research to their national needs. The barriers to such access are many and include lack of financial, scientific and infrastructural resources.
4. Biotechnology research has not been closely integrated with the problems and constraints confronting low-income farmers in the agricultural sector of developing countries. Biotechnology needs to be focused on some key problems within sustainable agriculture and rural development that historically have not been effectively addressed by conventional technologies.
5. Governments, scientists, non-governmental organizations, donors and CGIAR will have to consider the development of innovative mechanisms for the transfer of biotechnologies in developing country agriculture. Long-term public-sector funding will be necessary if the dissemination of agricultural biotechnology research is to benefit the poorer strata of society.
6. Over the longer term, there is little doubt that some biotechnological approaches to agricultural improvement could generate social, economic and environmental benefits if specifically targeted at the specific needs of poorer groups. While a vast range of approaches for the biotechnological improvement of such agronomic traits are either under study or in early development phases, given the current lack of focused public sector support for pro-poor agricultural biotechnology it is unlikely that poorer farmers will have economic access to such improvements in the short term.
7. Participation of poorer farmers and other stakeholder groups in developing sustainable agriculture and rural development is a key theme throughout Agenda 21. Greater impact of publicly funded biotechnologies on sustainable agriculture and rural development may result from including farmers’ groups in decision-making regarding the definition of sustainable agriculture and rural development objectives that might be met by agricultural biotechnology. Communication channels and constructive dialogue between upstream public-sector agricultural biotechnology researchers and downstream on-farm researchers and farmers’ groups are poor. There are currently no mechanisms for effective translation of farmers’ expressed needs into research action through appropriate "participatory problem transfer". Most public-sector bodies that either fund or conduct agricultural biotechnology research have no incentive mechanisms that would ensure that agricultural biotechnology research is targeted to the needs of poorer farmers or social groups. That is a public policy problem that can only be addressed by Governments and their institutions.
8. Agenda 21 proposes on-farm research in the development of non-chemical alternative pest management technologies. Biotechnology could contribute to the breeding of plant varieties or animal breeds tolerant to pests or pathogens that are currently controlled by agrochemicals, which could allow reductions in agrochemical use through the substitution effects of particular genes conferring tolerance.
9. Strategies for the sustainable use of genetic resources, such as resistance genes against pests or pathogens, are now emerging. The third CGIAR system review has proposed that CGIAR centres promote a global initiative for integrated gene management, which would,*inter alia*, promote more sustainable use of useful genetic resources.
10. A search through the scientific literature on biotechnology reveals a range of agricultural biotechnological research that could impact favourably on all of the priority areas of Agenda 21, chapter 14. However, the relevance of uncritically listing all biotechnology research which is under way and might meet sustainable agriculture and rural development objectives should be questioned. The development of a technology does not guarantee its widespread dissemination — especially to poorer social groups. When it comes to food security, it is the practical application of the research that matters, rather than the promise of the "pipeline" research orientation. The agricultural biotechnology research community lacks concrete examples of pro-poor applications of molecular-level biotechnology being put to use in farmers’ fields on a scale necessary to have an impact on rural poverty.
11. Over the longer term, there is much promising agricultural biotechnological research that in theory might be harnessed for sustainable agriculture and rural development objectives, such as increasing yields and sustainable utilization of plant genetic resources for food including:

* Apomixis, an asexual technology of plant reproduction that can provide economic incentives to replant harvested seeds;
* Micro-propagation and plant tissue culture technology (e.g., to generate disease-free plantlets of vegetatively propagated staple crops, such as cassava, potato, sweet potato, taro, bananas and plantains);
* Improved fermentation technologies;
* Improved technologies for generating biomass-derived energy;
* Generation of higher nutrient levels (e.g., pro-vitamin A, iron, essential amino acids) in nutrient-deficient staple crops, such as rice;
* Marker-assisted-selection strategies for improving agronomic traits in animal and plant varieties/breeds, including yield potential;
* Development of genotypes with abiotic stress tolerance (e.g., aluminium and manganese tolerant crops which can grow in acidic soils, salt tolerance, drought tolerance);
* Vaccines against animal diseases;
* Insect resistance;
* Bacterial, viral and fungal disease resistance;
* Better crop digestibility for animals and humans;
* Delayed overripening of fruits and vegetables (e.g., to reduce post-harvest losses).

1. Very few public-sector institutions or organizations are involved in the transfer of appropriate biotechnologies to the crops and farming systems of rural groups in developing countries, reflecting the current bias in agricultural biotechnology research to commercial markets. Internationally, there are only a handful of underfunded agricultural biotechnology initiatives (public or private sector) with an explicit focus on poorer farmers as their primary clients/markets. Some examples are the Center for the Application of Molecular Biology to International Agriculture; the FAO-facilitated Technical Cooperation Network on Plant Biotechnology for Latin America; the International Centre for Tropical Agriculture Cassava Biotechnology Network; and other biotechnology networks created and managed by the CGIAR international centres. Several national Governments of developing countries have good programmes on agricultural biotechnologies, such as Mexico, Argentina, Brazil, China, India and Egypt.
2. The Commission on Science and Technology for Development will address the topic "National capacity-building in biotechnology" in its current work programme. Particular attention will be given to agriculture and agro-industry, health and environment. The theme will include the transfer, commercialization and diffusion of technology, as well as bioethics, biosafety, biodiversity and regulatory matters affecting these issues to ensure equitable treatment. In its resolution 1999/61, the Economic and Social Council also recommended that the Commission initiate a dialogue that involves the private and the public sectors, non-governmental organizations and specialized biotechnology centres and networks to raise issues concerning global development in biotechnology (see also General Assembly resolution 54/201).
3. In 1991, the intergovernmental Commission on Genetic Resources for Food and Agriculture requested the preparation of a code of conduct on plant biotechnology, with the aim of maximizing the positive effects and minimizing the possible negative effects of biotechnology in agriculture. However, the Commission has suspended work on the draft, pending the completion of the negotiations for the revision of the international undertaking on plant genetic resources. At its eighth session, in April 1999, the Commission requested that a report on the status of the draft code of conduct be submitted at its ninth session, in 2001.

**Assessing impacts of biotechnology on health and the environment**

1. There are concerns about potential risks posed by some aspects of biotechnology. These risks fall into two basic categories: the effects on human and animal health, and the environmental consequences. Caution must be exercised in order to reduce the risk of transferring toxins from one life form to another, of creating new toxins or of transferring allergenic compounds from one species to another, that could result in unexpected allergic reactions. Risks to the environment include the possibility of out-crossing, leading, for example, to the development of more aggressive weeds or wild relatives with increased resistance to diseases or environmental stresses, upsetting ecosystem balance. There is also the potential loss of biodiversity, for example, resulting from the displacement of traditional cultivars by a small number of genetically modified cultivars, and the potential for increased crop vulnerability resulting from the possible widespread adoption of varieties with simple, monogeneic, disease resistance mechanisms. However, in principle, these latter effects are no different from those that may result from many conventional approaches to plant breeding.
2. Policy decisions taken in regard to biosafety regulations will have long-term implications for the sustainability of agriculture and food security. Many genetic engineering approaches to crop improvement arise from a lack of suitable conventional approaches to dealing with a particular agronomic problem or need. It appears that long-term negative implications for agriculture and food security can arise equally from having biosafety regulations that are either too lax or too stringent.
3. Genetic engineering approaches have considerably broadened the range of gene pools which are now accessible for crop improvement purposes. If countries expect to benefit from modern biotechnologies in their agriculture and food sectors, they will have to give serious consideration to the drafting of biosafety regulations that are tailored to meet their socio-economic needs. Biosafety regulations and standards for risk assessment need to be harmonized within eco-regions since environments are common across political boundaries.
4. The development of international norms in biosafety is essential. In 1995, the Conference of Parties to the Convention on Biological Diversity established a negotiation process to develop — in the field of the safe transfer, handling and use of living modified organisms — a protocol on biosafety, specifically focusing on the transboundary movement of genetically modified organisms resulting from modern biotechnology. After five years of negotiations, ministers and senior officials of over 130 Governments finalized a legally binding agreement for protecting the environment from risks posed by the transboundary transport of living modified organisms created by modern biotechnology, during formal negotiations to adopt the protocol, held at Montreal, from 24 to 28 January 2000.2The issues of biosafety and biotechnology are also to be addressed by the Codex Alimentarius, the joint FAO/World Health Organization (WHO) Commission that determines global food standards. It has set up an ad hoc intergovernmental task force on foods derived from biotechnology that is scheduled to meet from 14 to 17 March 2000 in Tokyo.
5. Biosafety assessment requires that risks, benefits and needs be given a balanced assessment in relation to genetically modified organisms. Many opponents of plant biotechnology cite biosafety as the key risk-based issue for the more stringent regulation of transgenic organisms. Much controversy has been generated over the safety of transgenic foods.
6. It should be borne in mind that in a biological sense, the inter-species genetic modification of foods is not inherently new. Many conventionally bred crops are by any biological definition transgenic, since they contain genes or segments of chromosomes from totally different crop species. Many of the biological phenomena which are often cited as unique biosafety issues for genetically modified crops actually also occur in conventional plant breeding or other biological processes involving non-modified organisms and in wild species.
7. In the context of biotechnology risk assessment, there is a widely held scientific consensus that risk is primarily a function of the characteristics of a product — whether it is a purified chemical or a living organism to be field tested — and is not per se a function of the method of genetic modification. However, the current legal definitions of genetically modified organisms upon which most biosafety legislation is being constructed are largely process- rather than product-oriented. The scientific consensus emerging from the vast range of biosafety studies of transgenic plants is that each case should be evaluated on its own merits and hazards. Hence, biosafety decisions might differ according to the particular type of transgene, crop, environment and end use involved.
8. There is no evidence to suggest that transgenic crops or biotechnology per se would either decrease or increase biodiversity in agricultural or in "natural" ecosystems. Within agricultural systems, plant biotechnology research could be applied to either increasing or decreasing genetic diversity, depending on research objectives. With modern biotechnological methods, the use of the genetic resources from wild crop relatives may actually increase. The selective advantage that a particular genetically modified organism will confer in the agro-ecological niche in which it is applied should be considered in risk assessment.
9. In general, any risks of transgenic crops to biodiversity should be assessed relative to other non-transgenic options. Most risk assessment studies regarding genetically modified organisms fail to do comparative studies to assess each particular risk relative to the levels of risk to health and environment from other options.
10. Many naturally occurring plant proteins and compounds can be anti-nutrients, toxic or allergenic. Indeed, a significant number of crop species are toxic if not cooked or prepared properly to reduce or inactivate such compounds. There is currently no scientifically accepted evidence to suggest that transgenic foods per se are any more or less toxic or allergenic for humans than their conventionally bred counterparts. Indeed, genetic engineering approaches and other research approaches are under way to develop "functional foods" or "nutraceuticals" which would contain lower levels of allergens and toxins or higher levels of beneficial compounds than conventional foods.
11. Consumers have a definite right to information and hence choice regarding which foods they purchase or eat. However, consumer information is based on the premise that the information provided to the consumer is of utility to the consumer in making an informed choice. Labelling is increasingly perceived as necessary by both the biotechnology industry and some Governments to meet consumer concerns, and several OECD countries require labelling of transgenic foods. The United States of America requires labelling of transgenic foods that are substantially different from their unmodified counterparts, including foods that could contain a potentially allergenic compound, such as a peanut protein or glutenins.
12. Since this is a new area in which many developing countries lack technical expertise, there is need for technical assistance and capacity-building on biotechnology and on risk assessment of genetically modified organisms to allow for adequate biosafety measures to be implemented by countries.