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BIOTECHNOLOGY AND SUSTAINABLE LIVELIHOODS—FINDINGS AND RECOMMENDATIONS OF AN INTERNATIONAL CONSULTATION

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In June 2001, ISNAR's Biotechnology Service (IBS) organized a consultation meeting for research scientists, centers of the Consultative Group on International Agriculutural Research (CGIAR), and donor and development agencies, to analyze various approaches and discuss case studies regarding the socioeconomic impact of biotechnology on the poor[1] *in developing countries. The consultation introduced the Sustainable Livelihoods Framework, developed by the UK Department for International Development (DFID), to further assess agricultural biotechnology inputs. Participants also defined selection criteria to identify future case studies examining the impacts of biotechnology on the livelihood of poor producers in developing countries.*

These contributions became part of the proposed project "Biotechnology and Sustainable Livelihoods—Examining Risks and Benefits," which will be implemented jointly by ISNAR, the International Food Policy Research Institute (IFPRI), and other cooperating international and national organizations. The purpose of the project is to quantify and qualify the actual or potential impact of agricultural biotechnology on the livelihood of rural farmers in developing countries, to improve the institutional capacity in developing countries to conduct this kind of research, and to generate first-hand information from selected study sites.

[1] There are several views as to what constitutes poverty. In this Briefing Paper, we focus on subgroups of communities able to take advantage of biotechnology innovations. In this sense, we are not talking about the "poorest of the poor," nor about urban or rural nonagriculturist poor communities.

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Introduction

By 2030, the world's population is expected to grow to 8.1 billion at a rate of over 75 million people per year.[2] Almost all of the population increases will occur in developing countries (FAO 2000) that can ill-afford additional population pressures. Based on a population-increase-only projection with per capita consumption remaining constant, world cereal production must rise from approximately 1.92 billion tons in 1990 to 2.88 billion in 2030 to match the demand.[3] Although the number of undernourished people in developing countries is expected to decrease, the global food-system situation will continue to be unacceptable. Some authors (Moore-Lappé et al. 1998) maintain that there is currently enough food to feed the world's population adequately; they argue the problem of world hunger is not one of quantity but of unequal distribution. However, even if we resolve the issue of distribution in the short run, the future growth in food demand will require increases in productivity from a decreasing stock of arable land. The challenge, therefore, is not only to feed more people, but to do so with less available arable land, fewer nonrenewable resources, less water, and fewer people engaged in primary agriculture (Conway and Ruttan 1999).

These population and resource facts, combined with a renewed commitment to fighting poverty, indicate that the main thrust of national and international policies aimed at solving issues of rural poverty and food insecurity must include broader agricultural and rural development objectives, such as significant increases in local food production. To escape from poverty, rural populations in developing countries depend directly or indirectly on increased agricultural productivity. Because the rural poor represent a significant percentage of the total population in developing countries, an innovation that increases productivity will have a major impact on food-security efforts and a nation's poverty.

Biotechnologies that are focused on smallholder problems, undertaken in an integrated manner and along with traditional research aimed at improving agronomic practices, can help poor farmers increase productivity (Pinstrup-Andersen, Pandya-Lorch, and Rosegrant 1999). Thus, while only part of a total solution that involves better market conditions, policies, and access to production resources, biotechnology can contribute to addressing poverty issues in developing countries.

But should agricultural development strategies for developing countries include biotechnology as one of their priorities? What is the impact of biotechnology on the environment, human health, and the livelihood of the rural poor? Should developing countries consider biotechnology at all? Debates surrounding these questions have generated passionate exchanges and controversies in many forums. It is, however, extremely important to ask these questions in the today's environment of declining public investments in agricultural research, where the majority of modern biotechnology applications are geared toward market-based economies or used for commodities in highly productive environments. Indeed, part of the criticism directed at biotechnology, in particular genetically modified (GM) crops, is that poor farmers and consumers stand to benefit very little from biotechnology. There is also very little information about the long-term costs, benefits, and risks associated with biotechnology, especially for the poor.

There is a pressing need to document both the positive and the negative effects of biotechnology in rural communities. This will be of value in the ongoing debate about biotechnology, and it will provide essential information to policymakers, research managers, elected representatives, and community leaders.

To address this need, and to advance thinking on the subject, ISNAR's Biotechnology Service (IBS)[4] organized an international consultation[5] among research scientists, potential institutional collaborators, the Centers of the Consultative Group on International Agricultural Research (CGIAR), and donor and development agencies in June 2001. This Briefing Paper summarizes the consultation's findings and recommendations. One of the objectives of the consultation was to review opportunities for using broader, multidisciplinary approaches to examine the effects of the adoption of biotechnology in developing countries at the community level. In this review, the participants examined a method titled the Sustainable Livelihoods Framework, developed by the Department for International Development (DFID) of the UK, and currently used by international organizations such as CARE, OXFAM, and IFPRI-SPIA[6] to guide

[2] FAO (2000) projections indicate that the world's population in 2030 may vary between 7.4 and 8.85 billion. This would imply a global demand for cereal production of between 2.54–3.03 billion tons. These estimates are a simplification because they assume constant levels of cereal consumption and ignore the complex links between population growth, income, and food production.

[3] Adapted from Dyson (1999).

[4] ISNAR's Biotechnology Service (www.isnar.cgiar.org/ibs.htm) is an independent advisor on policy and management issues related to agricultural biotechnology.

[5] Biotechnology and Rural Livelihood—Enhancing the Benefits, June 25–28, 2001. Consultation proceedings are forthcoming.

[6] CARE: Assistance and Relief Everywhere, Inc.; OXFAM: Oxford Committee for Famine Relief; IFPRI-SPIA: see page 5 of this Briefing Paper.

their impact assessment and intervention efforts. (See the section "Introducing the Sustainable Livelihoods Framework" on page 5 of this Briefing Paper.)

The participants discussed implementation approaches and defined selection criteria. They also discussed potential case studies that can quantify and qualify the actual or potential impact of agricultural biotechnology on the livelihood of poor rural farmers in developing countries. Selected cases will form part of a proposed project, to be funded by donor agencies.

For this meeting, biotechnology was defined as products arising from cellular or molecular biology and the resulting techniques produced by these disciplines for improving the genetic makeup and agronomic management of crops and animals (Cohen 1999). This definition allowed a focus on products arising from both traditional and modern biotechnology. Traditional inputs may include the by-products of tissue culture, micropropagation, or those used to eliminate diseases. Modern approaches may include the use of DNA diagnostic probes, recombinant vaccines, and products of genetic modification. In the case of GM products, we will emphasize the examination of products that claim to increase pest resistance, improve yield, improve tolerance against biotic and abiotic stresses, reveal nutritional benefits, and reduce the environmental impact. These characteristics may have the greatest impact in addressing the needs of poor farmers in developing countries (National Academy 2001).

The consultation's findings and recommendations have been incorporated into a proposed project "Biotechnology and Sustainable Livelihoods—Examining Risks and Benefits," to be implemented jointly by ISNAR, the International Food Policy Research Institute (IFPRI), and other collaborating international and national organizations.

The Impact of Agricultural Biotechnology: Evidence to Date

Various nongovernmental organizations (NGOs) and researchers opposed to biotechnology have portrayed biotechnology products as harmful to the environment (Clark 1998), to human health (Ho 1999), or to the socioeconomic status of small farmers (Shiva 2000). However, organizations and private-sector companies that are interested in developing the technology point to the benefits of biotechnology for farmers, the biosafety approval process, as well as the technology's potential for addressing certain problems in developing countries. How can we explain these divergent views? The answer involves a number of political, social, religious, psychological, and historical factors. For example, through strong political pressure, consumer groups in Europe concerned about biotechnology have contributed to a stop on the development of biotechnology products in the European Union. The USA and other countries such as China, on the other hand, have policies that are considerably more sympathetic towards the technology (Paarlberg 2000).

Both proponents and critics of biotechnology have manipulated information to support their positions. In some cases, preliminary results of scientific studies have been prematurely presented as facts to illustrate the positive or negative impact of biotechnology. In other cases, organizations have presented suspicions or potential risks as facts.[7] This manipulation only serves to emphasize the need for robust research that explains the benefits as well as the costs of biotechnology.

An often cited example of the potential damage to human health is the Ewen and Pusztai (1999) study published in *The Lancet*. As part of an experiment, rats were fed GM potatoes for 10 days. Some rats developed internal organ damage, and the authors linked this to the consumption of the transgenic potatoes. Kuiper, Noteborn, and Peijnenburg (1999), however, argued that the scale of the Ewen and Pusztai study was too small to warrant this conclusion and that the results cannot be extrapolated to implicate all GM foods.

In another well-known study, genes expressing proteins of the Brazil nut were inserted into soybeans (Nordlee et al. 1996). Early tests revealed that people allergic to nuts reacted to the modified soy products. The use of this particular gene technology was stopped.

These examples demonstrate it is necessary to consider potential health effects in a new transgenic crop. Proper biosafety approval processing and testing can identify risks before new products are released for use. The old maxim of "absence of evidence does not constitute evidence of absence"[8] still holds true. However, it is important to point out that even though a growing portion of the arable land of both the USA and Argentina is sown

[7] Examples can be found in "50 Harmful Effects of Genetically Modified Foods" by Nathan Batalion, available on-line at www.cqs.com/50harm.htm

[8] Commonly attributed to the renowned astrophysicist Carl Sagan.

with GM varieties,[9] there has not been one scientifically verified case of human health directly affected by the technology (Kaeppler 2000).

A research study conducted by Losey, Rayor, and Carter (1999) suggests that Monarch butterfly caterpillars that have been force-fed Bt corn pollen had lower appetites and higher mortality rates than the control group. In response to this study and to concerns by some environmentalist groups, six independent teams of researchers conducted studies examining the effects of Bt corn on Monarch butterflies. They all concluded that although the particular pollen used in the Losey, Rayor, and Carter experiment is highly toxic to Monarch butterfly larvae, the risk in field conditions is negligible.

Quist and Chapela, in a letter to the editor in *Nature* in 2001, claimed that some maize seeds collected in Mexico and analyzed by the authors reveal contamination by pollen from GM corn. This contamination may present an environmental problem since Mexico is the center of origin[10] of the traditional corn. In response to this conclusion, four groups of reviewers argued that the study's methodology and interpretation were flawed. Based on these reviews and the inconclusiveness of additional data and the analysis requested by the authors, *Nature* retracted the article. It printed the authors' responses and reviewers' comments to allow readers to judge the soundness of the research methodology of the original study. The authors of the article, as well as organizations for and against GMOs, subsequently accused each other publicly of intimidating researchers and pressuring them to abandon certain research projects and of using faulty data to advance a particular agenda. None of the participants in the debate, however, addressed the most important question of whether the contamination of traditional Mexican corn varieties by genetically modified organisms (GMOs) constitutes an environmental hazard or not.

One case of economic damage has been reported. It involves Starlink® maize in the USA. StarLink is the gene that produces the Bt toxin in maize. The US Food and Drug Administration approved Starlink maize only for cattle feed because the protein may cause allergies in some humans. Very small amounts of Starlink maize ended up in food destined for human consumption, and the inventor had to recall, purchase, and ultimately destroy the entire inventory. This highlights the problems involved in segregating conventionally and GM-bred products. Although several cases of allergies caused by the protein were reported in the USA, neither the country's Centers for Disease Control and Prevention nor the Food and Drug Administration could verify the claims.

Reports by the UK Royal Society (2002) and the Research Directorate-General of the Commission of the European Communities (2002) indicate that there has never been a scientifically documented accident involving GMOs. An EU publication that reviewed biosafety assessments of 81 projects funded by the European Commission between 1984 and 2000 concluded that substantial efforts have been made in the area of biosafety assessment and that there is an ever-increasing amount of data available about the risk characteristics of GMOs.

The assessment of the socioeconomic impact of biotechnology on rural development has been the subject of several studies, conferences, and discussions. There is a general lack of conclusive data, in part because biotechnology products are relative new, in part because there has been little interest in analyzing the socioeconomic impact of other, more established biotechnology innovations, such as micropropagation. ISNAR, among others, intends to fill this gap by providing comprehensive and rigorous impact assessments of various biotechnologies, particularly by examining those produced by the national agricultural research organizations in the developing countries.

Some excellent reviews of agronomic and socioeconomic studies exist, e.g., Marra, Pardey, and Alston (2002); Shelton, Zhao, and Roush (2002); and the Commission of the European Communities (2002). The main conclusion of these studies is that biotechnology varieties provide significant benefits to farmers. For example, farmers can use less pesticide or substitute it with less toxic ingredients. In some cases, the use of biotechnology may facilitate the adoption of erosion conservation methods, such as the no-tillage or reduced-tillage practices. In most cases, the benefits for the farmer outweigh the increased investments they have to make in the form of usage fees for the developers of the technology.[11]

The consultation

During the consultation meeting, participants presented studies that examined the benefits and economic impacts of GM products in selected developing countries. Most of the impact studies concentrated on insect-resistant cotton (Bt cotton), one of the most widely dis-

[9] Transgenic crops currently account for 20% of the US cotton crop, 50% of the US soybean crop, 25% of the US corn crop, and an estimated 95% of the Argentina's soybean crop (James 2001).
[10] The geographical area in which the species or taxon first arose.
[11] An opposing view is Duffy (2002).

tributed biotechnologies in the developing countries and well suited for small-scale farming.

The studies presented at the consultation were conducted in China (Huang et al. 2001), Mexico (Traxler et al. 2001), and South Africa (Beyers et al. 2001). They show that the adoption of Bt cotton leads to higher yields and a marked reduction in pesticide use, which can have substantial environmental and human health benefits. The planting of Bt cotton raised farmers' net benefits sufficiently to make up for the higher seed costs. During the planting seasons that were analyzed, farmers were shown to benefit the most, while seed companies and consumers benefited less. These conclusions are similar to studies conducted in developed countries (such as Falck-Zepeda et al. 2000).

The studies are an important contribution to the debate about the role of biotechnology in developing countries. They provide new information about the impact of biotechnologies and raise issues that need to be resolved. Few of the studies specifically addressed the effects of agricultural biotechnology on the environment and on humans, however, or addressed the broader aspects of poverty reduction and food security. ISNAR proposes adopting a broader approach in the form of the above-mentioned Sustainable Livelihoods Framework to study this particular impact of agricultural biotechnology. The suggested approach builds on a multicountry study by Adato and Meinzen-Dick (2002) for the CGIAR Standing Panel on Impact Assessment (SPIA) on the impact of conventional agricultural research. The CGIAR conducted impact assessment on the rural poor through different SPIA projects. SPIA commissioned IFPRI to conduct case studies using the Sustainable Livelihoods methodology. The rationale for using the methodology in this IFPRI/SPIA project was based on recommendations made in a literature review by Kerr and Kolavalli (1999), which showed that there were many pathways through which the rural poor can obtain benefits or incur costs arising from agricultural research. Some of these pathways were critical in arriving at a more complete measurement of the impact of agricultural research. The authors note that "[t]echnology's role in alleviating poverty is both indirect and partial; technology alone cannot overcome poverty, nor can continued poverty be blamed on improved technology."

The additional case studies in the proposed project are expected to lead to a better understanding of how different forms of agricultural research affect the lives of the poor.

Introducing the Sustainable Livelihoods Framework[12]

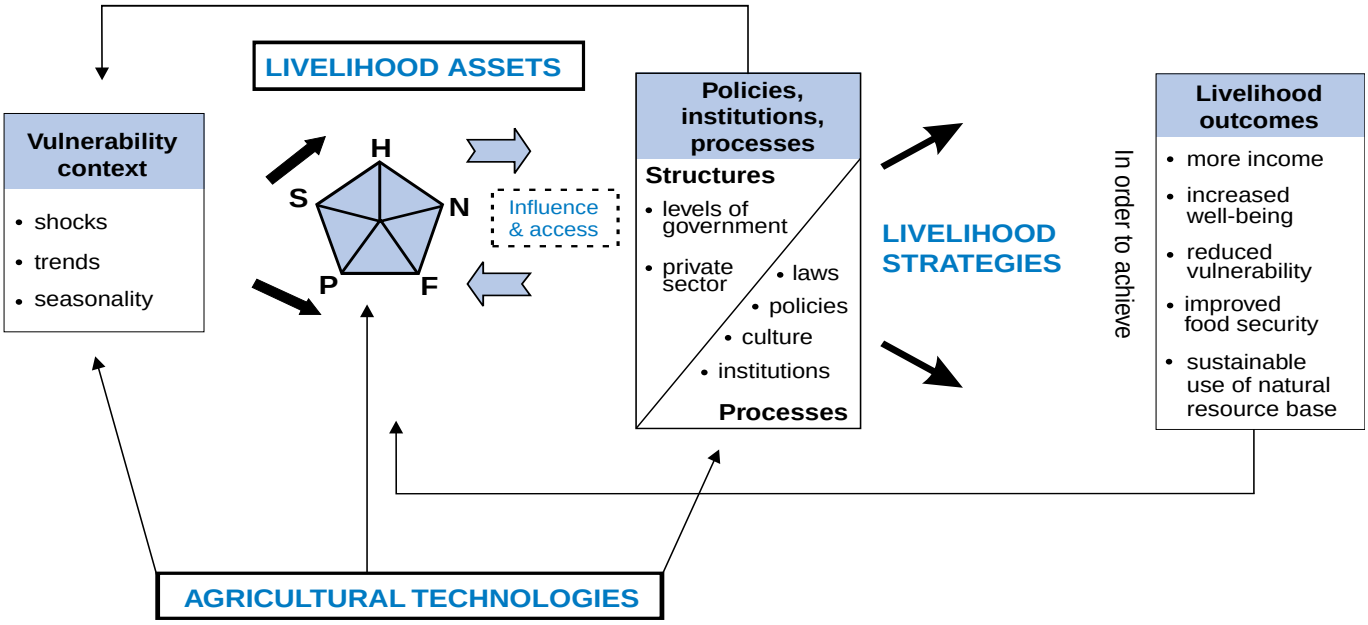
The Sustainable Livelihoods Framework enhances understanding of poverty and food insecurity by analyzing the relationships between relevant factors at the household, community, and regional levels. This approach explicitly examines the context in which people live in a rural community. By including concepts of vulnerability, assets, and empowerment, the Sustainable Livelihoods Framework goes beyond conventional socioeconomic measures of income or nutrition.

Figure 1 illustrates the overall Sustainable Livelihoods Framework. The framework is dynamic and recognizes changes due to external fluctuations and the results of people's own actions. The starting point of the framework is the vulnerability context within which people live. The vulnerability context is affected by external influences such as the weather and price changes. External changes may also affect the assets held by people in a particular community. The framework recognizes five types of assets: human ("H" in the figure); natural (N), financial (F), physical (P), and social (S), which all need to be examined. The assets interact with policies, institutions, and processes in shaping the choice of livelihood strategies. These, in turn, shape the outcomes of livelihoods, which are the types of impacts we are interested in.

The Sustainable Livelihoods Framework draws on many considerations often excluded from agricultural economic impact studies. It is often difficult to see, however, how agricultural research and technologies may fit into the framework. Figure 1 shows three ways for agricultural research to enter this framework: by affecting the vulnerability context, through linkages to the asset base, or as part of the policies, institutions, and processes. These dimensions will be explicitly included in the analytical framework of the proposed study.

Many factors may intervene in a Sustainable Livelihoods approach. Agriculture is only one part of people's livelihoods, and agricultural research and technologies affect only part of the total farming system. Understanding other factors that impinge on livelihood can be critical for improving the ultimate impact of agricultural research. We will collect quantitative and qualitative data for pathways, allowing strong economic and social analysis to facilitate their evaluation.

[12] This section is based on Meinzen-Dick (2001).



Key to "livelihood assets:" H = human; N = natural; F = financial; P = physical; S = social

Figure 1. The Sustainable Livelihoods Framework.
***Source*: Meinzen-Dick 2001**

Limitations and Challenges

A fundamental difficulty when determining the impact of a technology is the lack of a clear definition of poverty and sustainable livelihoods. The discussions during the consultation did not provide such a definition but did provoke further debate on how to describe the characteristics of poverty, sustainable livelihoods, and poverty allevation. For example, by adopting a certain technology and capturing the benefits, farmers who are not "the poorest of the poor" can help alleviate poverty through, for instance, providing employment. One participant cited an example of shrimp farmers in Thailand who employ migrant laborers from poor areas and neighboring countries. Food products thus produced help lower the price of food, improving the food security of poor urban populations. The proposed project will provide more information on the impact of technologies in the rural sector and help define what constitutes poverty and sustainable livelihoods.

Additional conceptual challenges raised by participants regarding the impact of biotechnology on livelihoods relate to the following:

- **The limited experience in and availability of data for this type of research.** Most biotechnology applications are relatively new and need to mature, hampering the ability to conduct multi-year, ex post economic analyses. Coupling a Sustainable Livelihoods approach with ex ante economic analyses will be difficult, as the researcher needs to make many assumptions about uncertain effects on the existing community links. It will be useful to begin by identifying the livelihood asset base, "vulnerable" groups in a specific community or region, and potential links affected by the introduction of a particular technology.

- **Finding the right balance between ex ante and ex post approaches to impact assessment.** These approaches are highly complementary, yet each has its own inherent strengths and weaknesses.

- **The difficulty of partitioning overall economic impact at the household or individual level.** This limits the utility of the Sustainable Livelihoods Framework to analyze livelihood impacts in detail. There will be many indirect effects, especially on the urban poor, and they will be difficult to analyze. This limitation is closely related to the ability of researchers to identify, quantify, or qualify the line of causality from intervention to reduction of poverty and food insecurity.

- **The institutional and regulatory context for the delivery and farm-level adoption of products from biotechnology.** This is an important factor to con-

sider, especially as regulatory hurdles may delay the dissemination of transgenic products. It adds a new dimension to the analysis, further complicating future studies.

- Related to the above point, there are uncertainties in foreseeing and evaluating potential concerns regarding the environmental and biosafety aspects as well as the public acceptance of GM food products.

Crucial Issues

Participants raised crucial questions, mostly from a methodological standpoint, as to whether biotechnology is different from other technologies, and if so, what the differences are. Answers to these questions will affect the design of the proposed study, as well as the discussion on research and development and other policies.

The consultation identified several unique characteristics of biotechnology:

- **Market structure and market power.** Biotechnology products are primarily researched, developed, and marketed by the private sector. This is a departure from Green Revolution technologies such as the semi-dwarf varieties of wheat, which were primarily developed by the public sector. Exclusivity of ownership of biotechnology traits may encourage private-sector companies to influence the input markets. However, the different intellectual property rights laws and market structures in different countries make it difficult for a private firm or public institution to exercise market power.

- **Distributional implications.** Closely related to market power are the distributional implications involved in biotechnology. The distribution of benefits among producers, consumers, and the innovator(s) may vary within a country or between developed and developing countries. There may also be differences from country to country in consumers' and producers' access to benefits.

- **Environmental and regulatory issues.** There is widespread disagreement about the risk characteristics of GMOs. Although no environmental damage or human injury involving GMOs has ever been documented, some aspects of the risk profile of GMOs remain unknown. Risk assessments studies can help reduce the probability of adverse results.

- **Acceptance by consumers.** The difference between the USA and the European Union in consumer acceptance of GM products has implications for developing countries that want to export GM products. As a result of the strong opposition to GMO-related research in Europe, Paarlberg (2002) argues that developing countries will have less access to biotechnologies that can help address their agricultural constraints.

The Proposed Project

An analysis of the factors that determine the adoption and diffusion of biotechnology at the rural level is badly needed. There is also an urgent need to analyze the costs of and benefits of products of both traditional and modern biotechnologies.

Based on discussions and interactions during the ISNAR consultation, we advocate a multidisciplinary, community-based approach to respond to the questions and concerns about the impacts of products derived from biotechnology on the livelihood of rural communities.

The overall **goal** of the proposed project is to enhance the livelihoods of people in rural communities. The **purpose** of the project is to improve the understanding and analysis of the positive and negative impacts of biotechnology on rural livelihoods, as well as to develop the capacity for such research among partner institutions in developing countries. With improved knowledge of the impacts of biotechnology on rural livelihoods, national agricultural research programs can weigh the benefits versus the costs and risks of biotechnology inputs more realistically and apply this knowledge to setting better-informed priorities in their research agendas.

The project will conduct case studies to provide actual, community-level information and data. The project thus answers to concerns raised in past meetings and reports that this type of information is unavailable.

ISNAR and IFPRI propose implementing this project jointly, together with institutional partners in the selected countries.

The participants suggested the following specific objectives for the proposed study:

- **Measure the economic gains within a market.** Horizontal measurement of the economic gains is done by measuring the gains of both consumers and producers. Vertical measurement is done by measuring the difference in gains between various inputs and outputs produced at different levels of the production process.

- **Assess the contribution of the gains to people's livelihoods.** This should include economic impacts within the context of a comprehensive Sustainable Livelihoods construct at the household level.

- **Analyze household-level impacts using a broader societal framework.** This includes an assessment of the adoption of positive and negative externalities of biotechnology on employment, environment, public health, vulnerability, and risk.

Considering the challenges mentioned above, consultation participants recommended that ISNAR develop a research project that builds on and adds diversity to the ongoing and completed studies, by including the sources of technology (public, private, international), the types of applications (e.g., cell biology, diagnostic techniques, genetic engineering), and the geographical diffusion.

Further suggestions for selecting case studies included: (1) select study sites with both adopters and non-adopters of a new technology, so that key adoption factors can be identified, and (2) strike a balance between ex ante and ex post studies, rather than choosing one particular approach. Concerning the latter point, it may not be possible to develop a detailed research methodology that will be suitable to all of the selected case studies. Instead, the basic research questions should be formulated so that the design of the particular method will be customized for each individual case.

Participants also indicated that a *unifying theme* for the case studies would facilitate comparison of the cases, such as assessing products in which developing-country institutions have played an important role in developing the technology. Given the limited GM cases available, participants agreed that this project can include ex ante[13] as well as ex post studies. Participants recommended the following selection criteria as one method for evaluating prospective case studies (table 1 presents a list of all of the potential case studies that were presented at the consultation). Each case should

1. potentially reduce poverty among small farmers;

2. enhance the variety of cases selected in terms of region and type of technology;

3. when possible, address the lack of information on impact available for non-GM technologies, such as tissue culture and micropropagation;

4. provide a base for strong national research program participation in conducting the research studies;

5. provide information on the benefits, costs, and risks associated with a technology.

Therefore, wherever possible, we will primarily select technologies and commodities produced by national agricultural research organizations, with additional examples taken from international agricultural research and the CGIAR Centers. This approach gives preferential treatment to the national agricultural research systems by developing methodologies, experience, and institutional capacity that will further augment research on CGIAR commodities, using livelihood impact investigations. Participants recommended that ISNAR try to elicit the participation of economic research institutions in developing countries. We will make this recommendation operational by identifying and selecting reputable local institutions in each participating country.

The case studies in table 1 are products developed by national and international research organizations and private, not-for-profit institutions in developing countries. Some case studies, such as MARDI's virus resistant papaya, represent a collaborative effort with a private-sector company and a product that humans will consume. This may have trade implications and consumer issues that these countries need to analyze. The Colombia and Zimbabwe case studies on plantain and sweet potatoes are the products of a novel bottom-up and participatory approach to conducting research. The Colombia, Kenya, and Sri Lanka cases are the products of international research centers, which may provide an alternative pathway to the dissemination of scientific knowledge. In contrast, the China, India, and Thailand case studies are the products of national research institutes that have obtained sufficient scientific capacity to develop their own biotechnology applications.

[13] Ex ante studies are needed to ensure the products proposed to be developed will fit the needs of poor producers. In our project, the ex ante analysis of livelihoods will involve people in rural communities to drive the analysis process. All the cases under consideration will also include information of the counterfactual case (without biotechnology). This will enable us to examine the dynamic adoption process as it unfolds over time.

Table 1. Potential Cases Presented at ISNAR's Consultation Meeting, June 2001

Technology	Product	Trait	Location	Organization
Micropropagation				
▪ Disease-free plant material	Plantain / cassava	Virus-free plant material	Colombia	Colombia-Netherlands biotechnology program
	Banana	Virus-free plant material	Kenya	KARI
	Banana	Virus-free plant material	Sri Lanka	FAO-IAEA
	Sweet potato	Virus-free plant material	Zimbabwe	Zimbabwe-Netherlands biotechnology program
Genetic modification				
▪ Bt toxin expression	Potato	Insect resistance	Colombia	CIP
	Rice	Insect resistance	Asia	IRRI
▪ Stress tolerance / Bt or CPTi expression	Tomato / rice	Cold tolerance/Insect resistance	China	CAAS
▪ Disease resistance & quality	Papaya	Virus resistance & delayed ripening	Malaysia	MARDI
Other applications				
▪ Various		Bio-villages concept	India	MSSRF
▪ Recombinant vaccine	Cattle	East coast fever	Kenya	ILRI
▪ Disease diagnostics	Shrimp	Yellow head virus	Thailand	BIOTEC

BIOTEC National Center for Genetic Engineering and Biotechnology
CAAS Chinese Academy of Agricultural Sciences
CIP International Potato Center
FAO Food and Agriculture Organization of the United Nations
IAEA International Atomic Energy Agency
ILRI International Livestock Research Institute
IRRI International Rice Research Institute
KARI Kenya Agricultural Research Institute
MARDI Malaysian Agricultural Research and Development Institute
MSSRF M.S. Swaminathan Research Foundation

Summary and Conclusions

Recent advances in agricultural applications of modern biotechnology show a significant potential of agricultural biotechnology to contribute to sustainable gains in agricultural productivity, reducing poverty, and enhancing food security in developing countries. As these innovations are increasingly adopted, impact assessment becomes a critical tool for addressing potential socioeconomic and environmental costs and benefits. A key question, however, is whether conventional economic impact assessments is comprehensive enough to address the complex nature of a rural community in a developing country. To further knowledge of the impact assessment of biotechnologies in developing countries, IBS organized a consultation to analyze various approaches and case studies regarding the socioeconomic impact of biotechnology on the poor in developing countries.

This Briefing Paper introduces a more recent development, the Sustainable Livelihoods Framework, and proposes to apply this framework to products derived from biotechnology in order to quantify and qualify the impact of biotechnologies in developing countries. The Sustainable Livelihoods approach is a comprehensive framework that both requires and facilitates multidisciplinary work to assess the impact of interventions in a community. The Sustainable Livelihoods Framework considers the vulnerability context, policies, a community portfolio of assets, institutions, and the linkages between these components. It is well suited to address the shortcomings of conventional socioeconomic impact assessment methodologies in analyzing poor communities in developing countries.

There are some conceptual and implementation issues in the Sustainable Livelihoods approach regarding the specific nature of biotechnology innovations, such as the

issue of biotechnologies becoming a private good and thus opening the possibility of excessive pricing by the innovator. These still need to be resolved. It is important to point out that adopting the framework may require a change in the attitude of the impact assessor, as well as that of development agencies and research institutions, in that, in the end, the *community* guides the research. This bottom-up approach to research identification and evaluation means that approaches other than biotechnology need to be explored.

Taking into consideration the recommendations of the participants at the international consultation, ISNAR, IFPRI, and their collaborators in national and international research institutes plan to launch a joint agricultural biotechnology impact study entitled "Biotechnology and Sustainable Livelihoods—Examining the Risks and Benefits." This project will enhance our knowledge of biotechnology's positive and negative impacts on the livelihood of rural communities in developing countries. The project will also empower the national agricultural research institution's ability to perform broad-based research that will improve their decision-making capabilities.

Planned work

ISNAR is currently pursuing funding for this project from external sources. A concept note to support five case studies for three years with a total budget of USD 1.3 million has been submitted to donor agencies. ISNAR has initiated a collaborative effort with the International Potato Center (CIP) in Lima, Peru, and the Corporación Colombiana de Investigación Agropecuaria (CORPOICA) of Colombia, in order to examine the ex ante impact of insect-resistant potatoes in Colombia. This project will incorporate many of the concepts of the Sustainable Livelihoods Framework, providing a benchmark for future studies.

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