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It focuses on relevant technical topics and on innovative actions carried out by IICA and its Member

States in response to challenges and opportunities involved in achieving food security, sustainable agricultural development and prosperity in rural communities.

The five articles contained in this issue, written by IICA professionals, deal with some of the challenges and opportunities for agriculture today, addressing topics such as climate change, water and agriculture, agrobiotechnology, precision agriculture, women rural entrepreneurs and food-borne diseases.

Each one, while pointing to current and future problems related to the demand for safe foods and products to meet the needs of a growing population, also offers interesting proposals for solving them. Emphasis is placed on the urgent need to make production more efficient, increase farmer incomes and improve the quality of life for rural inhabitants while balancing production, markets and the environment.

**COMUNICA** is also available in digital form at [www.iica.int](http://www.iica.int) in the hopes of expanding our readership outside the hemisphere.

# The growing strength of rural women micro-entrepreneurs in Latin America and the Caribbean

Melania Portilla R., Hannia Zuñiga<sup>1</sup>



## KEY WORDS

Rural microenterprises  
Women  
Jobs  
Income  
Gender  
Rural development

Whether these small rural businesses manage to become consolidated enterprises depends on a combination of factors related to business performance and structural aspects such as the development of rural economies, the availability of public goods and services, market access, the performance of labor markets and gender-related disparities. One of the most important factors is how well organized a group of producers is and how it manages its productive activities. However, few countries have national policies and strategies intended to support small businesses and institutions that assist them in their endeavors. Not surprisingly, only a small number of initiatives manage to grow and consolidate their position in increasingly competitive markets.

## *More visible but still not receiving the recognition they deserve*

Organized groups of rural women producers devoted to agricultural and other activities are now commonplace. In some cases, it is women who manage the initiatives; in others, women play a key role in small, family-run businesses or enterprises.

When rural women work in the informal sector, it is generally regarded as a survival strategy and as the feminization of rural poverty. In fact, women micro-entrepreneurs are involved in a wide variety of situations and contexts, both in rural areas and throughout their respective countries.

To illustrate the ground that small rural women's enterprises have gained since the 1990s, and give the reader some idea of their potential, it is worth looking at three interrelated factors.

- a) The **modernization** of agriculture in the 1980s, to which rural women contributed as food producers. This, however, took place as primary agriculture was increasingly becoming a precarious activity, women were taking on the role of heads of household and rural poverty was becoming feminized (ECLAC, 2002).
- b) The **complexity of the process** via which large numbers of women have been integrated rapidly into labor markets in LAC, particularly in rural areas, but not on an equal footing. There is a marked tendency for rural women to engage in non-agricultural activities.

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- c) The “novelty” of self-employment opportunities, with women setting up small businesses or rural enterprises in labor markets that reproduce gender disparities that work against them. Gender is also a major cultural factor in terms of the practice and values of women as entrepreneurs, in contrast to the traditional construct of business as a male-dominated field.

## Women in agriculture

The recognition of rural women’s contribution to agriculture and the rural milieu is a much more recent development than some care to admit. It was not until the 1970s, when the United Nations declared the “Decade of Women” and the debate on the crisis in development gave rise to structural adjustment programs, that certain efforts were made to establish the participation of women in issues that were of national concern.

Those first efforts, based on the “women in development approach,” resulted in investments being channeled toward them and their being included in the agendas of development institutions. However, the projects and programs implemented with the women in development approach were aid-oriented and urban-centric, and designed to make up for the handicaps they faced. This did little to foster the inclusion of rural women in more dynamic development processes on equal terms or to establish their true contribution as part of the economically active population (EAP) in domestic economies.

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Years later, an IICA study on the contributions made by women food producers in 18 countries in the region highlighted the continued invisibility of the work of rural women in LAC (Kleysen and Campillo 1996). The study revealed that many women who worked on small family agricultural units were not even considered part of the EAP and their contribution to agricultural production was underestimated in the figures for the manpower involved. The assumption was that women’s contribution on family plots or farms was an extension of their domestic work, for which they received no remuneration. As they were not paid a wage, their activity was not included as work in official estimates of economic activities. The study estimated that the contribution of women was between 1.25 and 5 times greater in the Central American countries in the 1990s than official figures suggested.

Although the invisibility and underreporting of rural women’s contribution to agriculture are long-standing problems, the structural adjustment programs in the 1980s and the modernization of rural areas and agriculture created new conditions for rural women in LAC.

Small-scale primary agriculture has declined or deteriorated and large-scale agribusinesses based on traditional agricultural products have undergone a process of modernization. At the same time, labor mobility has intensified, with the rural population migrating to other national and international labor markets and more schooling becoming an increasingly important factor for young people in rural areas. Furthermore, the efforts to breathe new life into small-scale agriculture by adding value are being stepped up. Non-agricultural activities such as tourism (in its different forms) are also on the rise and rural economies are diversifying through the preservation of environmental resources.

In this new context, there is clear evidence of the feminization of the countryside, with women increasingly being forced to assume the role of head of the household, in addition to the key role they play in subsistence farming or small-scale family agriculture (with surplus production being sold). Furthermore, one of the biggest changes that took place in the 1980s was the increase in the integration of rural women workers into the production of nontraditional



products for export and into the services sector, as employees, self-employed workers or people who combine agricultural work with other income-producing activities. There was a sharp increase in the incorporation of women into the workforce in the 1980s<sup>2</sup>, in a relatively short period of time and on markedly unequal terms.

### *The integration of rural women into non-agricultural activities*

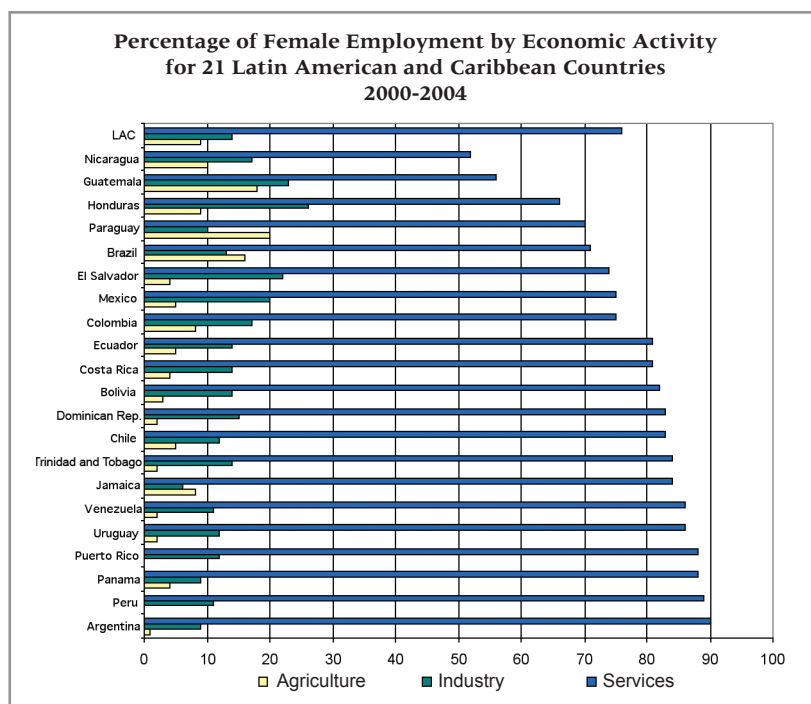
**Chart 1** shows the trend in women's participation in different economic activities during the period 2000-2004. In particular, there was a growing tendency for women to participate in economic activities other than primary agriculture, such as industry and the

services sector. Women's roles in production clearly became more diversified. Nonetheless, it is difficult to make a realistic comparison of the increase in women's participation in production due to the underemployment of women in previous years.

By 2006, rural women in LAC accounted for nearly 44% of the non-agricultural EAP, but only 27% of the agricultural EAP. However, the importance attributed to non-agricultural jobs is due to the quality of the income, which complements earnings obtained from agricultural activities but does not replace them (IICA 2006).

The integration of women into the labor market may have begun speeding up in the 1980s but in rural labor markets they remain at a clear disadvantage as far as their male counterparts are concerned.

**Chart 1**



Source: World Bank 2006

<sup>2</sup> The integration of rural women into the labor market was a turning point in the 1980s, difficult to measure because they worked mostly in the informal sector. This trend had already been observed in earlier years.

*Women themselves frequently state that their involvement in small productive organizations is due to the flexibility that such enterprises offer, allowing them to combine income generation with domestic and reproductive tasks.*

Although gender gaps have narrowed over the last decade, the rates of open unemployment for women remain significantly higher than those for men<sup>3</sup>.

**Chart 2** shows the trend in the gap between the rates of male and female rural unemployment for the period 1995-2000. Women may be playing a bigger role in rural economic activities but it has not necessarily improved their lot.

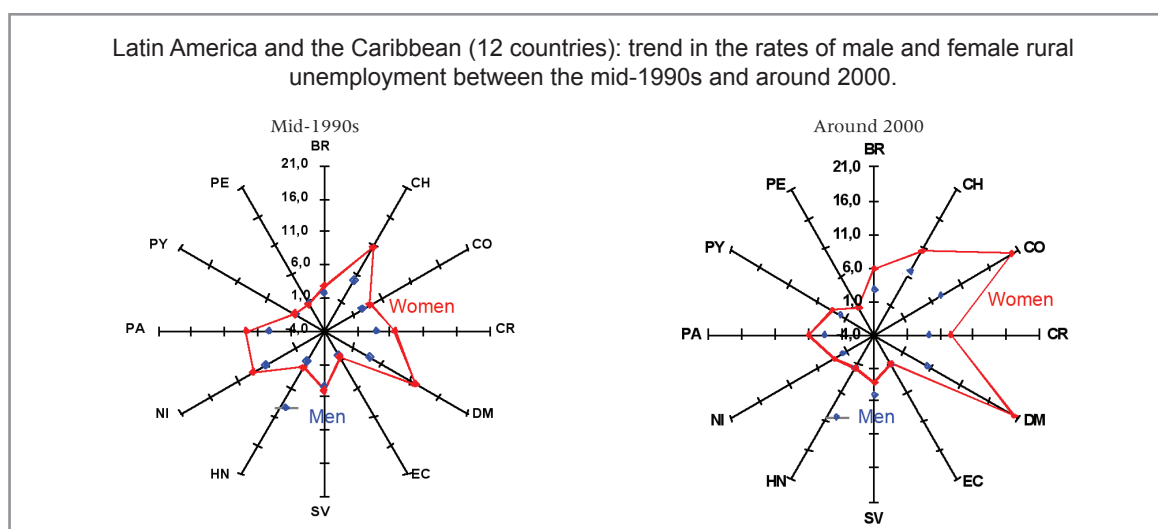
In the circumstances, it is reasonable to assume that women are more inclined to create new enterprises, self-employment initiatives and small businesses because of the unfavorable conditions they face in labor markets.

While the relationship between the greater participation of women in small rural businesses (SRB) and the inadequate, disparate conditions in labor markets may not necessarily be one of cause and effect, complex gender-related factors do come into play when men and women have to decide for which economic sector to opt. The structural conditions of labor markets do not take into account nor solve the problem of the reproductive tasks of rural women workers, so women must find a practical solution to the daily dilemma they face.

Women themselves frequently state that their involvement in small productive organizations is due to the flexibility that such enterprises offer, allowing them to combine income generation with domestic and reproductive tasks.

This has not increased women's income, nor resolved the structural gender disparities that affect them. What it shows is the fine line that separates the development of microenterprises from the opportunities generated by labor markets. When markets fail to create an enabling environment or offer rural women workers ways of performing their reproductive tasks, subcontracting and income generation in the informal market become more attractive options. Underestimating women's work via different mechanisms (including the reproductive tasks that rural women must perform) is a handicap to rural women workers gaining access to sectors that are more productive. It is no coincidence that the highest rates of indigence and rural poverty are to be found among female salaried agricultural workers, subsistence agricultural producers, income-producing entrepreneurs and members of indigenous communities (Portilla and Avendaño 2005).

**Chart 2**



Source: Prepared using IDB data (2003)

<sup>3</sup> The same report notes that El Salvador is the exception, where this indicator fell to a lower level than the figure for men.

*Women are generating  
new concepts of  
rural entrepreneurship*

Despite the contradictions described above, the growing number of women managing small rural businesses (SRB) constitute not only a practical solution to an unmet need but an alternative for greater economic and social inclusion accompanied by major innovations.

Women's participation in business activities makes them more self-aware and they come to realize the importance their productive role, because it generates new values and ideas about business practices. All business activities involve a certain degree of planning and management but the experiences of women entrepreneurs are particularly interesting because they are required to perform a multifunctional role. Both the simplest and most complex women's enterprises (networks, corporations and consortia) tend to establish mechanisms that place emphasis on the well-being of families (health, housing, credit, etc.) as benefits that go hand in hand with the organization of business and productive activities.

The above undoubtedly poses complex challenges in terms of the policies and investments required if these small businesses are to turn a profit. Certain examples demonstrate that adjusting mechanisms and investments can tap the potential of women in the different areas of business development. Women have become the main clients of micro-finance institutions and programs worldwide, such as the Grammeen Bank in Bangladesh, whose initiatives have been replicated with the same success in countries all over the globe (Latifee 2006). In LAC, it is harder for rural women to obtain formal credit than men and to register goods in their name for use as collateral. On the other hand, it has been shown that when credit actually reaches women through alternative microfinance mechanisms, they are excellent credit recipients.

Our ideas about entrepreneurship and what a businessperson is also need to change. There are aspects of gender that entail new values, capabilities and competencies that need to be incorporated into

*Our ideas about entrepreneurship and what a businessperson is also need to change. There are aspects of gender that entail new values, capabilities and competencies that need to be incorporated into the social and economic constructs of what being "successful" in business means, which influence the models, instruments and resources used to develop enterprises.*

the social and economic constructs of what being "successful" in business means, which influence the models, instruments and resources used to develop enterprises.

Far from being gender-neutral, many of the instruments used today to encourage the development of business skills are male-biased and based on pre-established relationships between public (productive) activities and private (reproductive) activities that view the latter as less important than, and dependent on, the former.



*Small businesswomen are not simply workers trapped in the informal sector or entrepreneurs unable to make a living.*

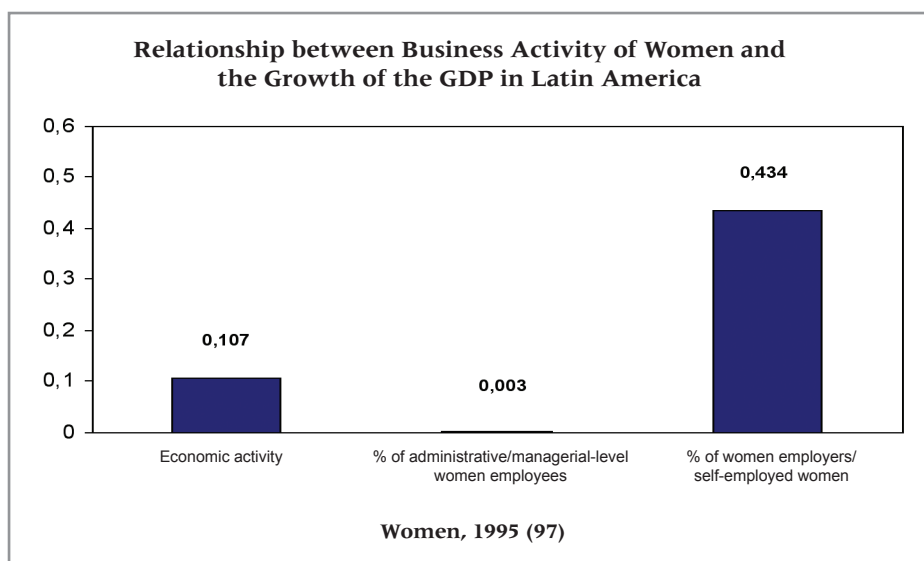
From a different perspective, studies like that of Weeks and Seiler (2001) shed light on novel aspects of the economic potential of businesswomen, even at the level of domestic economies. One of the main conclusions of this study is that when micro-enterprises run by women are efficient and do well, there tends to be a positive relationship between self-employed women entrepreneurs and women employers and the growth of gross domestic product, as illustrated in **Chart 3**.

Consequently, small businesswomen are not simply workers trapped in the informal sector

or entrepreneurs unable to make a living. Like other micro-entrepreneurs, their work is the only basic productive factor that the vast majority of rural businesswomen possess, and it needs to be strengthened by giving them access to, and the use of, goods and services adapted to their needs.

Capacity building and financial organization can enhance the potential of rural women involved in small businesses. However, access to public goods and productive assets is a determining factor if they are to make the qualitative leaps that will unleash their true potential.

**Chart 3**



Note: Percentages derived from companies with computers

**Source:** Weeks and Seiler 2001



## Final considerations

To tap the potential of small rural businesses as generators of substantive economic and social opportunities, it is necessary to analyze the trends in rural and urban labor markets. However, there are disparities in the integration of rural women workers into labor markets that undermine their human development and the productivity of economic activities. But these are the conditions under which rural businesswomen must struggle to find new work options, through innovative initiatives that could be underpinned by public and private institutions.

The consolidation of these efforts poses two key challenges:

1. Promotion of the organization of rural women producers at levels that substantially increase their opportunities and benefits, and their impact on the economic development of territories (i.e., networks, consortia, corporations).
2. Formulation and management of differentiated policies, strategies and investments designed to consolidate the different types and groups of small businesses, including investment in capacity building and public goods and services at the territorial level.

*A coordinated effort of this kind would do far more to turn small businesses run by rural women into dynamos of rural economies than poverty alleviation mechanisms.*

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## Resumen / Resumo / Résumé

### **La creciente fuerza de las microempresarias rurales en América Latina y el Caribe**

**L**as microempresarias rurales forman parte de la renovada geografía humana de actores sociales y agentes económicos que han sobresalido en las últimas dos décadas en la región. Pese a una serie de condiciones desventajosas que día con día enfrentan, las empresas de mujeres parecen estar

contribuyendo no sólo a generar empleos e ingresos en el medio rural, sino a la creación de nuevos conceptos en torno al potencial de la pequeña empresariedad en América Latina y el Caribe (ALC). Este documento brinda algunos elementos para una mejor comprensión del contexto en que la mujer microempresaria gana visibilidad, lo cual permite dimensionar el potencial de estos pequeños negocios rurales para la superación de patrones de desarrollo asimétricos.

.....

### **A força crescente das microempresárias rurais na América Latina e do Caribe**

**A**s microempresárias rurais formam parte da renovada geografia humana de atores sociais e agentes econômicos que vêm se destacando nas duas últimas décadas na região. Apesar de enfrentarem diariamente uma série de condições desfavoráveis, as empresas de mulheres parecem estar contribuindo não

apenas para a geração de emprego e renda no meio rural, mas para a criação de novos conceitos quanto ao potencial do pequeno negócio na América Latina e no Caribe (ALC). Este documento mostra alguns elementos que ajudam a compreender melhor o contexto em que a mulher microempresária ganha visibilidade, o que permite dimensionar o potencial dos pequenos negócios rurais para superar padrões de desenvolvimento assimétricos.

.....

### **La force croissante des microchefs d'entreprise rurales en Amérique latine et des Caraïbes**

**L**es microentreprises rurales font partie de la nouvelle géographie humaine d'acteurs sociaux et d'agents économiques qui sont apparus au cours des deux dernières décennies dans la région. Malgré une série de conditions désavantageuses auxquelles sont confrontées les entreprises dirigées par des femmes, celles-ci

semblent contribuer non seulement à créer des emplois et des revenus en milieu rural, mais aussi à faire naître de nouveaux concepts au sujet du potentiel de la petite entreprise en Amérique latine et dans les Caraïbes. Le présent document apporte quelques éléments visant à faire mieux comprendre le contexte dans lequel la femme chef de microentreprise acquiert une visibilité, ce qui permettra d'évaluer dans quelle mesure ces petites entreprises rurales peuvent aider à dépasser les modèles de développement asymétriques.

# Climate change, water and agriculture

Adrian Rodriguez Vargas<sup>1</sup>

*“The complex interrelationship between environmental change and agricultural production will become one of the most significant policy issues, in both developed and developing countries, in the first few decades of the 21st century. Global and regional climate change will modify both agricultural production capacity and its location, and the intensity of agricultural production will contribute to environmental change at both regional and global levels.” (Ruttan 1991: 25)*



## KEY WORDS

Climate change  
IPCC  
Latin America  
Agriculture  
Water  
Adaptation

of its most important findings is that the increases in temperatures observed since the mid-20th century are due to human activities. It also presents evidence of many long-term changes in climate, such as variations in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.

This raises two questions: what will be the effects of global warming? And, what urgent actions need to be taken? With regard to the first, the report suggests that climate change will not be neutral in its impacts. The countries most adversely affected will be those in the tropical and subtropical regions, where most developing countries are located and poverty and hunger are widespread. In those regions, the effect on agriculture would be extremely negative. With respect to the second question, the report provides evidence to support the design of public policies. However, since the IPCC is a scientific body, it does not make recommendations.

The latest report of the Intergovernmental Panel on Climate Change (IPCC)<sup>2</sup> is conclusive. It says that “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level” (IPCC 2007b: 5). Over 800 scientists and 400 lead authors in more than 130 countries contributed to the report. One

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<sup>2</sup> The report is divided into four volumes, which deal with: a) the scientific evidence; b) impacts, adaptation and vulnerability; c) mitigation; and, d) a synthesis. At the time of writing (mid-April 2007), only the summaries for policymakers of the first two volumes have been made public, namely, IPCC 2007a and IPCC 2007b.

The objective of this article is to highlight the challenges and the opportunities for adapting Latin American agriculture to climate change, considering not only the expected impact on the sector but also the likely impacts with regard to the availability of water.

**Table 1. Anticipated impacts of climate change in Latin America.**

1.	By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia. Semi-arid vegetation will tend to be replaced by arid-land vegetation. There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America.
2.	In drier areas, climate change is expected to lead to salinisation and desertification of agricultural land. Productivity of some important crops are projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones soybean yields are projected to increase.
3.	Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation.

Source: IPCC 2007a: 12

### ***The impacts of climate change on agriculture***

The fact that the impacts of climate change are not neutral is evident in the case of agriculture. There are clear winners and losers. Or at least, depending on the scale of climate change, “some losers will lose more than others.” The IPCC report (2007a: 8) suggests the asymmetric impacts on agriculture will be as follows:

- Crop productivity is projected to increase slightly at mid to high latitudes for local mean temperature increases of 1-3°C, depending on the crop, and then decrease beyond that in some regions.
- At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C), which would increase the risk of hunger.
- At the world level, potential agricultural production is projected to increase with increases in regional average temperatures of 1-3°C, but above this it is projected to decrease.

- Increases in the frequency of droughts and floods are likely to affect local production negatively, especially in subsistence sectors at low latitudes.

Given these regional asymmetries, one of the biggest concerns is how climate change will affect the possibilities of achieving the Millennium Development Goals, especially regarding the efforts to reduce hunger. What, then, will be the effects on the global food supply?

A study published by Bosello and Zhang (2005), with projections through 2050, suggests that climate change will have a limited impact on the world’s food supply and well-being. However, it does stress that there will be major distributional consequences and the biggest negative effects will be concentrated in developing countries situated in tropical and subtropical regions. Poverty and hunger are rife in these countries, which were also identified in recent IPCC reports as the most vulnerable to climate change.



## *The issues involved in adapting agriculture to climate change*

The relationship between climate change and agriculture is complex. On the one hand, the effects of climate change - especially changes in temperature, precipitation and water levels, and the increase in extreme weather events - force farmers to take action to adapt to them. On the other, agricultural activities can play a role in mitigating the greenhouse effect that causes climate change.

Where adaptation is concerned, it is important to consider the different ways in which the socioeconomic system can respond to the situation. There are three possible areas on which it can focus: adaptation at the farm level, adaptation at the national level and adaptation at the global level (Bosello & Zhang 2005: 3-5).

- **Adaptation at the farm level** refers to any action undertaken by farmers to adapt to changes in the climatic conditions. This includes measures such as changes in the planting time, frequency and location of crops; the adoption of new varieties or combinations of different types of crops; the adoption of technologies and cultivation systems that help preserve the original environmental conditions (e.g., irrigation); and research and development on new varieties that can adapt better to climate change.
- At the **national level**, climate change may lead to changes in the use of agricultural inputs (e.g., land, water, genetic quality of seed) and in output levels (quantity and quality) that spread to the

**Table 2. Possible impacts on agriculture of changes in the frequency and intensity of extreme weather events and in the climate, and of increases in sea level.**

<i>As a result of ...</i>	<i>it is safe to say that</i>	<i>that ...</i>
warmer days and fewer cold days and nights, warmer days and nights and more warm days and nights in most regions,	it is virtually certain,	yields will increase in cold environments and decrease in warm environments, and plagues of insects will increase.
the increased frequency of warm spells/heat waves in most regions,	it is quite likely,	yields will decrease in cold regions due to heat stress and the danger of wildfires will increase.
the increased frequency of events involving heavy precipitation in most regions,	it is very likely,	crops will be damaged and soil eroded, and land will not be usable because water has been extracted from the soil.
the increased frequency of events involving heavy precipitation in most regions,	it is likely,	land will become degraded, yields will fall, crops will be damaged and lost, more livestock will die and there will be a greater risk of wildfires.
the increase in the area affected by drought,	it is likely,	crops and coral reefs will be damaged and the roots of trees will be weakened.
the increase in cyclone activity, the increased frequency of extreme events involving rising sea levels (excluding tsunamis),	it is likely,	irrigation water, estuaries and freshwater systems will become salinized.

Source: IPCC 2007a: 16

rest of the economy. The resulting changes in relative prices can lead to crops and inputs being replaced, and to variations in the demand for, and supply of, agricultural and non-agricultural goods. The links between the impacts of climate change and variations in relative prices call for new agricultural technologies and practices to be generated that affect prices. The greater the flexibility of the economic system, the smaller will be the impacts.

- At the **global level**, the impacts of climate change on agriculture will vary from region to region, depending on the latitude where countries are located, the local environmental conditions, the responses from the socioeconomic system and institutional factors. In an increasingly integrated world, this could trigger changes in the flows of factors of production, goods and services, and relative prices. Therefore, the distribution of crops across regions and countries and agricultural trade flows could undergo major modifications in the future.

Mendelsohn (2000: 583-600) distinguishes between private and joint (public) adaptation. Private adaptation is when farmers act individually, meeting their own costs and reaping the benefits. Joint adaptation occurs when all farmers enjoy the benefits but each bears his own costs.

If adaptation to climate change in agriculture has positive externalities<sup>3</sup>, then individual actions by farmers (private adaptation) will result in less adaptation than society needs. This justifies public policies to encourage adaptation. Examples of public adaptation in agriculture include research and the development of new species or varieties and species with different structures from current ones, the provision of irrigation infrastructure, agro-hydro-ecological zoning, the delivery of information and the development of public early warning systems.

### *Studies on the adaptation of agriculture to climate change in Latin America*

Few studies have been carried out in Latin America on how farmers are responding to climate change. The World Bank recently undertook a study entitled *Climate Change and Rural Poverty*, with support from the Cooperative Program for Agrifood and Agroindustrial Technology Development in the Southern Cone (PROCISUR) and the Cooperative Agricultural Technological Innovation Program for the Andean Subregion (PROCIANDINO). This study looked at four countries in the Southern Cone (Argentina, Brazil, Chile and Uruguay) and three in the Andean Region (Colombia, Venezuela and Ecuador). Some 2000 farmers on the following five types of farm were surveyed:

- Crops without irrigation.
- Crops with irrigation.
- Crops and livestock without irrigation.
- Crops and livestock with irrigation.
- Livestock only.

The study explored several aspects of the relationship between climate change and agriculture, including:

- An analysis of crop choices (Seo & Mendelsohn 2007a).
- An analysis of the choice of different types of crops, livestock, a combination of crops and livestock and irrigation, as adaptation options (Mendelsohn & Seo 2007).
- An analysis of the impact of climate change on the net income of farmers and land rents (Seo & Mendelsohn 2007b). The study also looked at three climate change scenarios, based on atmospheric oceanic global circulation models: a moderate scenario, an intermediate scenario and an extreme scenario<sup>4</sup>.

<sup>3</sup> When a person who carries out an action is not the only one to benefit from it, the action is said to have "positive externalities."

<sup>4</sup> The moderate scenario is based on the Parallel Climate Model (PCM); the intermediate scenario, on a model from the Center for Climate Systems Research (CCSR); while the extreme scenario uses a model from the Canadian Climate Center (CCC).

Not surprisingly, in the first two analyses the empirical evidence shows that the choice of agricultural activities and irrigation is sensitive to climatic variables.

The analysis of the different types of crops chosen as adaptation options revealed that the important climatic variables were temperature and precipitation. The study suggests that climate change will lead to crops being substituted. In particular, there will be a shift away from potatoes and wheat in favor of fruits and vegetables (Seo & Mendelsohn 2007a: 6-11).

The model of possible choices - crops, livestock, crops with livestock and irrigation - is interesting because it includes irrigation. The results with regard to the climatic variables that lead to irrigation being used are not surprising. Among the variables on which farmers base their decision to adopt irrigation are important ones like summer precipitation and winter temperatures. The variables that are of greatest concern to farmers who combine crops with livestock are summer precipitation and winter and summer temperatures (Seo & Mendelsohn 2007a: 10-19).

Other results suggest that the relative rate of return on investment in irrigation declines as temperatures rise and farmers in areas where precipitation is high are less likely to adopt irrigation. The chief limitation of the study is that it does not take the availability of water into account as a key variable in the decision whether to use irrigation.

The analysis of the impacts of climate change on land rents and farmers' net income is based on a model in which farmers maximize their net income, subject to conditions exogenous to their farms, which include climatic variables. The results confirm that net income and land rents are sensitive to those variables (Seo & Mendelsohn 2007b: 10-17). An interesting aspect of the results is that it is possible to differentiate between the impacts for small and large farmers. Both types of farms are sensitive to climate but the negative effect on the income of small farmers<sup>5</sup> is greater.

The results of the study are extrapolated to all Latin American countries for the year 2100, differentiating between small and large farmers (**Table 3**). In general, the results confirm the findings of the recent IPCC report on impacts, adaptation and vulnerability.

**Table 3. Impacts of climate change on land rents in Latin America in 2100, under different climate change scenarios.**

<i>Farmers</i>	<i>Moderate scenario</i>	<i>Extreme scenario</i>
Small farmers	Aggregate positive benefits, with changes by location: <ul style="list-style-type: none"> <li>• Positive for farmers in cold climates,</li> <li>• Negative in hotter regions of Venezuela, Colombia, the northern parts of the Southern Cone and Central America.</li> </ul>	Negative results in all locations.
Large farmers	Positive results in general, except in northern South America.	Negative results across the board, with variations in different locations. Possible benefits in Argentina, Chile, Peru and Mexico.

*Source:* Seo & Mendelsohn 2007b: 17-19

<sup>5</sup> For the purposes of the study, small farms are those less than 30 ha. in size.

The authors note that the study has several limitations:

- a) there is no information about water resources,
- b) the effect of carbon fertilization is not considered,
- c) the only thing that changes in the future is the climate. The effects of technical change are not considered and it is assumed that the prices of goods and labor do not change with the climate (i.e., relative prices remain the same), and,
- d) farmers in the future can adapt as readily as they can in the present. The capital required and other adaptation costs are not considered.

### **Water in the discussion about adaptation to climate change in agriculture**

A study by the Stockholm International Water Institute (SIWI) and the International Water Management Institute (IWMI) presented to the United Nations Commission on Sustainable Development in May 2004 highlighted the importance of water for achieving the Millennium Development Goals regarding the reduction of hunger, and the need to use water more productively in agriculture. The study's projections suggest that the additional water required to produce the food needed to reduce hunger and malnutrition by the year 2025 is equivalent to all the water currently used to support all aspects of life in society. These concerns are also important for the adaptation of agriculture to climate change.

At the local level, adapting to climate change in agriculture basically means being able to adapt, at different points in time, to situations in which there is either too much water or not enough, which

will also affect other water uses, such as human consumption and energy production.

Therefore, when we analyze adaptation options such as irrigation it is important to consider their effects on the availability of water, as well as the competing needs of other sectors of the economy.

Rosenzweig *et al.* (2004: 345-360) did a groundbreaking study that deals with these issues. The authors set out to examine the implications for the reliability of irrigation of changes in water availability and the demand for water for crops. The study also explores how effectively different adaptation options maintain the level of reliability.

The authors develop a methodological approach that combines climate change scenarios<sup>6</sup> with agricultural, hydrological and planning models<sup>7</sup>. Based on this, they study the availability of water for agriculture under changing climate conditions and make the corresponding projections for agricultural production, population, technology and economic growth. The study covers large agricultural regions that produce soybean and corn in Northern Argentina, Southeast Brazil, Northeast China, the Hungarian and Romanian parts of the Danube Basin and the Corn Belt in the USA. These regions have different socioeconomic, environmental, technological and climatic conditions; however, with the exception of Northeast China, they all have sufficient water for agriculture under current climatic conditions (Rosenzweig *et al.* 2004: 347-351).

The evidence suggests that in the most water-rich areas studied there will be sufficient water for agriculture in the climate change scenarios analyzed. With respect to the cases studied in Latin America, Northern Argentina occasionally experiences problems with the supply of water for agriculture under current conditions and those problems could be exacerbated and investments required to relieve water stress in the future. The outlook is brighter in the south of Brazil, where it appears that water for agriculture will be plentiful in the future.

<sup>6</sup> The study combines information from the following global climate models: a) Geophysical Fluid Dynamics Laboratory (GFDL - Version R30); b) Goddard Institute for Space Studies -NASA; c) Mark Plank Institute; d) United Kingdom Met Office Hadley Center (HadCM2); e) Canadian Climate Model (CGCM2).

<sup>7</sup> The models used were: a) the CERES model, to assess the water needed for corn and soybean (i.e., the demand for water); b) the WATBAL model, to assess the impact of climate change on the flow of water in watersheds (i.e., the supply of water); and c) the WEAP model, for projecting, planning and assessing multiple demands for water.



## *Climate change, population growth and economic development will affect the future availability of water for agriculture*

The study includes various simulations to determine whether the area under irrigation could be expanded, as an adaptation option<sup>8</sup>. The results suggest that only Brazil could easily expand the area under irrigation under the climate change conditions studied. The reliability of the water system would be undermined in the other regions.

The authors also point out that even in relatively water-rich areas, changes in the demand for the resource will affect agriculture due to climate change. That, coupled with increased demand from urban growth, will require timely improvements in crop varieties, irrigation and drainage technology, and water management. In short, climate change, population growth and economic development will affect the future availability of water for agriculture (Rosenzweig *et al.* 2004: 345).

The study mentions certain options for agronomic adaptation to climate change, such as variations in planting schedules and the use of varieties with genetic characteristics like heat tolerance, vulnerability to pests and sensitivity to pesticides. It also says that both yield and water use should be taken into consideration when planning adaptation to climate change from a genetic resources perspective (Rosenzweig *et al.* 2004: 357). Other factors are the need to consciously conserve and manage genetic diversity.

With regard to water resources, in some regions, too much water could be more damaging than drought; climate change may even alter the seasonal availability of water. Therefore, where agriculture is concerned the adaptation of water resources must include improvements in irrigation and drainage technologies. Of the cases studied, Brazil is best placed to increase the area under irrigation. In the other regions, it would intensify the stress in the water system (Rosenzweig *et al.* 2004: 356-7) (**Table 4**).

### *The implications for public policy*

In Latin America, some countries have made efforts to adapt, particularly through the conservation of key ecosystems, early warning systems, risk management in agriculture, strategies for managing droughts, floods and coastal areas, and disease surveillance systems. However, the effectiveness of these efforts is undermined by the lack of basic information and monitoring systems; insufficient capabilities and appropriate political, institutional and technological frameworks; low incomes; and settlements in vulnerable areas (IPCC 2007b: 12).

The above highlights the need for public policies to support adaptation to climate change in agriculture that promote greater integration of the agricultural and water resource sectors. There are several implications as far as adaptation is concerned:

- 1. Government intervention is justified.** A number of factors justify public policymaking to promote adaptation to climate change in agriculture. According to Mendelsohn (2000: 590-59), one is the existence of positive externalities to guide or correct the adaptation actions undertaken by private agents (e.g., by eliminating subsidies that promote the inefficient use of irrigation in agriculture). Another factor is equity in the international context, given the scientific evidence that the poor, tropical countries will be the most affected. Furthermore, the results suggest that small farmers are more sensitive to changes in climate. Yet another factor is timely access, especially for small farmers, to information about future changes in climate, their impacts and possible adaptation options.

The characteristics of adaptation to climate change in agriculture mark it out as a public good. However, there is no guarantee that joint adaptation will be efficient, since there may be differing views about what kind of adaptation

<sup>8</sup> These exercises did not include the United States.

**Table 4. Some facts related to water, agriculture and climate change.**

<p>Agriculture is the biggest consumer of water worldwide.          In the USA, agriculture uses 87% of all extracted water.          In the USA, approximately 68% of all groundwater extracted is used for agriculture.</p>
<p>It takes roughly 100 times more water to produce 1 kg of animal protein than to produce 1 kg of vegetable protein.</p>
<p>Approximately 16% of the world's cropland is irrigated.          Around 33% of the world's food is produced on irrigated land.          Irrigation, especially using groundwater, uses large amounts of energy to pump the water. In the USA, some 10% of the total energy expended each year in the agricultural sector is used in irrigation.</p>
<p>In the USA, some 12% of farmland is irrigated and produces 27% of the value of all crops. However, this percentage does not include the costs to the government of supplying and subsidizing a large percentage of the water used for irrigation.</p>
<p>The amount of water that reaches plants is put at less than 40% worldwide.</p>
<p>Many things can be done to conserve water, such as:</p> <ul style="list-style-type: none"> <li>■ using surge flow irrigation instead of flooding and channel irrigation techniques. Farmers in Texas, USA, are utilizing 38-56% less water for irrigation thanks to this innovation.</li> <li>■ irrigating at night to reduce evaporation. This technique can improve efficiency by 200-300%.</li> <li>■ using low-pressure sprinklers, which improves water efficiency by 60-70% compared with high-pressure sprinklers.</li> <li>■ using the low-energy precision application (LEPA) technique, which can enhance efficiency by 88-99%.</li> <li>■ using drip or micro-irrigation techniques, which are up to 95% more efficient. However, this technology is expensive and requires very clean water.</li> </ul>

*Source: Pimentel et al. 1997: 97-106*

is desirable, and disputes about the payment mechanism for public adaptation; while private agents may expect to be remunerated for their efforts (Mendelsohn 2000: 593).

At the national level, policies and strategies that strengthen or correct the responses of farmers and other private agents may be relevant to influence developments at the farm level. At the global level, actions should be channeled through multilateral international cooperation mechanisms, such as the environmental conventions.

2. **Better technologies are required to manage both too little and too much water in agriculture.** The study by Rosenzweig *et al.* (2004) points to the growing importance of

both irrigation and drainage technologies. This is important in wet areas, since analyses of the relationship between climate change and agriculture tend to focus on the impacts on dry areas and irrigation as an adaptation option.

3. **Efficient water management.** Efficient water management is essential for agriculture to adapt to climate change. It calls for policies such as the reduction of subsidies for the water used in agriculture, the development of water markets, the introduction of controls on the demand for water, investment to ensure that water is available when and where it is needed and, in general, the design of incentives to encourage farmers to conserve water and soil resources (Rosenzweig *et al.* 2004: 357; Pimentel *et al.* 1997: 107).



The study by the SIWI and the IWMI (2004: 4) highlights five challenges related to public policies that are relevant in this regard.

- a) Productivity: close the productivity gap between what is being produced now and what could be produced, through interventions that enhance water productivity. This is undoubtedly a major challenge. As the title of the report suggests, it means obtaining more nutrition for each drop of water used.
- b) Technology: facilitate the dissemination and use of new technologies for enhancing water productivity.
- c) Cultural practices: identify and influence unsustainable consumption patterns that increase the demand for water-intensive foods.
- d) Ecological issues: identify the minimum criteria for ecological services to protect aquatic ecosystems against water depletion.
- e) Economic concerns: identify unsustainable agricultural subsidies and trade barriers, especially those that affect regions where water is scarce.

- 4. Institutional management and development.** No provisions exist at the international level keyed to the need for adaptation to climate change. The Kyoto Protocol, the principal international climate change agreement, focuses strongly on

mitigation. Therefore, as Rosenzweig *et al.* (2004) emphasize, institutional adaptation is essential, along with continued technological improvement and investment in the water and agriculture sectors. This calls for greater coordination between institutions in the environment sector, especially those responsible for water management, and the different institutional bodies in the agricultural sector.

### *Corollary*

The IPCC document points up the need for public policies to support private efforts to adapt to climate change in agriculture that explicitly address the repercussions for water resources. This has major implications for the agenda of international cooperation agencies, especially for the countries that will be most affected by climate change. The agencies should provide support in at least five areas:

- a) the development of policy frameworks;
- b) the development of institutional frameworks that make it possible to address the problems using an integrated approach;
- c) the formulation of investment projects required in the water and agricultural sectors;
- d) capacity building; and,
- e) the generation and transfer of relevant knowledge.

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## *Resumen / Resumo / Résumé*

### **Cambio climático, agua y agricultura**

**E**l informe reciente del Panel Intergubernamental sobre el Cambio Climático (IPCC) presenta evidencia científica concluyente acerca de la certeza del cambio climático y sus efectos asimétricos entre países desarrollados y en desarrollo, especialmente en el sector agrícola. El objetivo de este artículo es destacar retos y oportunidades

para la adaptación de la agricultura latinoamericana al cambio climático, y considerar no sólo los impactos esperados en dicho sector, sino también los impactos previstos en la disponibilidad de agua. En el documento se enfatiza el carácter de bien público que tiene la adaptación en la agricultura. También se presentan implicaciones de política pública, derivadas de conocimiento actual sobre los vínculos entre cambio climático, agua y agricultura.

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### **Mudança climática, água e agricultura**

**O** recente relatório do Painel Intergovernamental sobre Mudanças Climáticas (IPCC) apresenta evidência científica conclusiva acerca da certeza das mudanças climáticas e seus efeitos assimétricos entre países industrializados e países em desenvolvimento, especialmente no setor agrícola. O objetivo deste artigo é apontar desafios

e oportunidades para a adaptação da agricultura latino-americana às mudanças climáticas, considerando não apenas os impactos esperados no setor, mas, também, os efeitos previstos na disponibilidade de água. O documento enfatiza a natureza de bem público da adaptação na agricultura. Também apresenta as implicações para as políticas públicas, decorrentes do conhecimento atual sobre os vínculos entre mudança climática, água e agricultura.

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### **Changement climatique, eau et agriculture**

**L**e rapport du Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC), publié récemment, présente des preuves scientifiques concluantes au sujet de la certitude du changement climatique et de ses effets asymétriques dans les pays développés et les pays en développement, en particulier dans le secteur agricole. Le but du présent article est de mettre en évidence les défis et les possibilités qui

attendent l'agriculture latino-américaine dans son adaptation au changement climatique, en considérant non seulement les impacts prévus dans ce secteur, mais aussi les répercussions anticipées sur les ressources en eau. Dans cet article, l'accent est mis sur le caractère de bien public que revêt l'adaptation dans le secteur agricole. Sont également présentées les implications, pour les politiques publiques, des connaissances actuelles sur les liens entre le changement climatique, l'eau et l'agriculture.

# Precision agriculture

*New tools to improve technology management in agricultural enterprises*

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Daniel Marçal<sup>2</sup> and Emilio Ruz<sup>3</sup>



## KEY WORDS

Spatial and temporal variability  
Localized management  
Global positioning system  
Geographic information systems  
Remote sensing  
Variable rate technologies  
Geo-statistics

equipment to till the land and plant, grow, harvest and process agricultural products has resulted in significant increases in food production. As a result, the 1990s saw the adoption of a new approach to agricultural land management that is based on the identification and interpretation of in-field spatial variability, known as precision agriculture.

The Cooperative Program for the Development of Agrifood and Agroindustrial Technology in the Southern Cone (PROCISUR) and IICA have been working together for years, promoting the adoption of new technological discoveries and advances in the region. For some six years, since people first began talking about this topic, PROCISUR and IICA have been supporting cooperation actions aimed at disseminating and developing precision agriculture technologies that are suited to conditions in the countries of the region. Experts from more advanced countries have contributed different visions and experiences related to this technology, which is relatively new in the region. This first stage culminated with the publication of the book *"Agricultura de Precision: Integrando conocimientos para una agricultura moderna y sustentable,"* which was used as the basis for preparing the present document, the objective of which is to present the basic concepts of precision agriculture and information related to the development and adoption of this technology around the world.

**T**he modernization of agricultural practices is emerging as a new challenge given the need to ensure the environmental and economic sustainability of production. The response on the part of the research, innovation and extension sectors linked to agriculture has been to generate technologies that will make it possible to quantify the variability that occurs naturally in fields, so that inputs can be applied in the right amount, at the right place and at the right time. Further, the effective use of new agricultural machinery and

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*All of this led to precision agriculture being defined as a number of techniques aimed at optimizing the use of agricultural inputs based on the quantification of in-field spatial and temporal variability.*

### ***Application of the concept of precision agriculture***

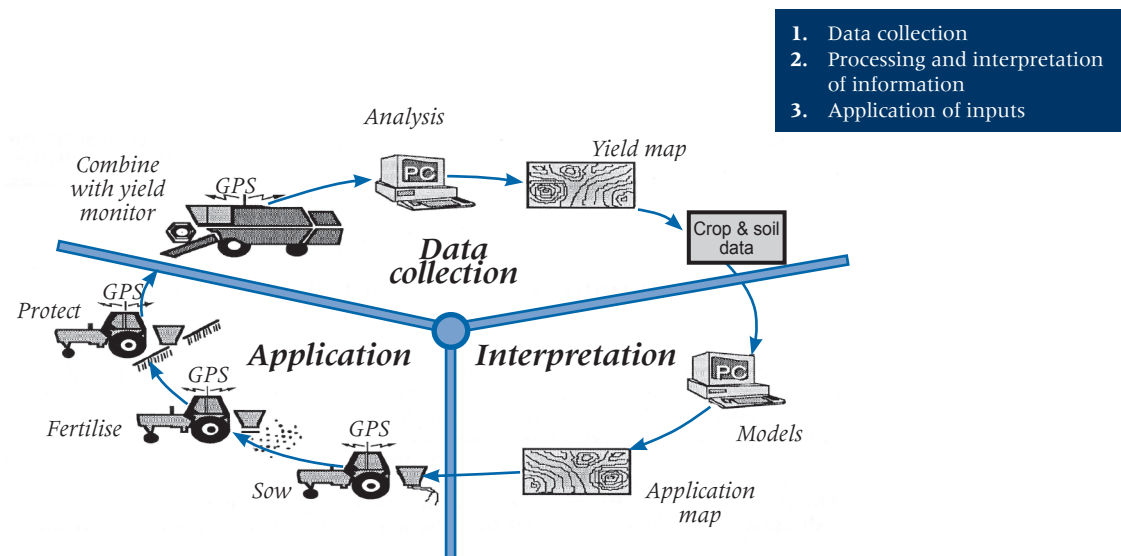
In the 1970's, a new type of agriculture began to take shape thanks to studies on the automation of agricultural machinery. When global positioning systems became available for civilian use in the late 1980s and early 1990s, it was possible to develop intelligent equipment that allows for the localized management of cultural practices, with more efficient application of inputs. This reduced the environmental impact and, as a result, the cost of producing food decreased.

All of this led to precision agriculture being defined as a number of techniques aimed at optimizing the use of agricultural inputs (seeds, agricultural chemicals and corrective treatments) based on the quantification of in-field spatial and temporal variability.

The technology does not consist only of measuring the existing variability in a field, but also of adopting management practices based on that variability. According to Robert (1999), the practice of identifying in-field variability or the factors that affect production in agricultural ecosystems is not new. What is different is the possibility of identifying, quantifying and mapping that variability. Furthermore, it is possible to geo-reference fields and apply inputs in different amounts and only when and where needed.

Precision agriculture calls for a more precise application of inputs based on the localized management of variations in yield in a given area. In contrast, in traditional agriculture, inputs are applied on the basis of average values.

The use of precision agriculture technologies can be divided into three stages (**Figure 1**):



**Fig. 1.** The three stages of precision agriculture

**Source:** AGCO 2005

The application of precision agriculture technologies can begin, for example, at harvest time, with a yield map or the identification of soil variability represented on yield and/or soil fertility maps, respectively (Figure 2).

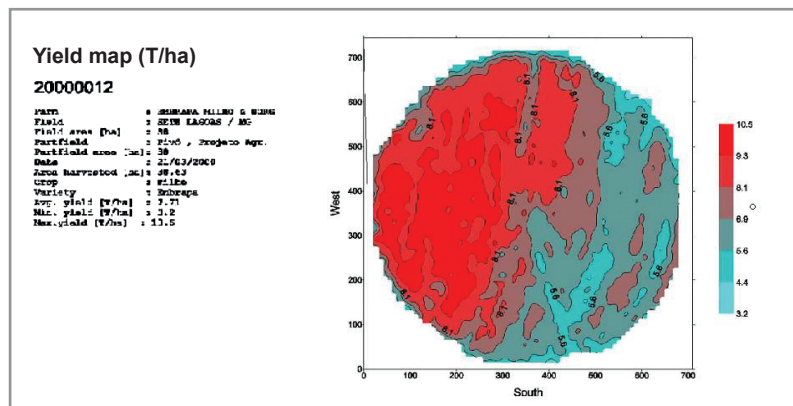


Fig. 2. Corn yield map, 2002 planting season

Source: EMBRAPA, Corn and Sorghum Experimental Station, Sete Lagoas, MG, Brazil

The study of soil and crop variability makes it possible to determine trends in yield in a single area over time, taking into account variations in climate and changes in soil. When the yield and/or fertility of a field do not vary, there may be little incentive for adopting precision agriculture techniques in order to

increase production. This is not the case, however, in terms of managing agricultural enterprises.

When production levels vary considerably, it may be beneficial to adopt these techniques because they reduce the distortions normally found in fields.

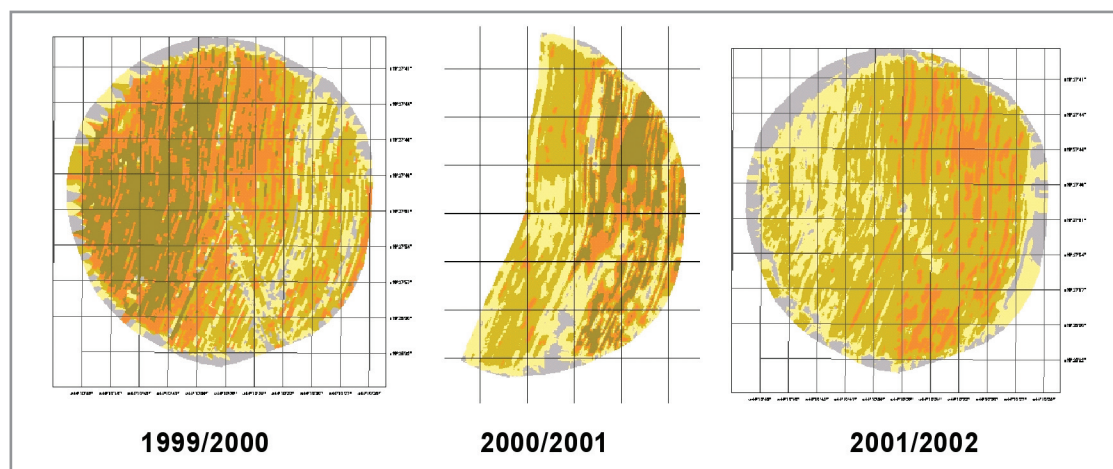


Fig. 3. Temporal variability of corn yield, 2000, 2001 and 2002 harvests/seasons.

Source: EMBRAPA, Corn and Sorghum Experimental Station, Sete Lagoas, MG, Brazil



To understand and apply precision agriculture, it is necessary to define the following basic concepts:

- **Spatial variability:** differences in production in a single field, for a single season and harvest (**Figure 2**)
- **Temporal variability:** changes in production in a single field, in different seasons (**Figure 3**).

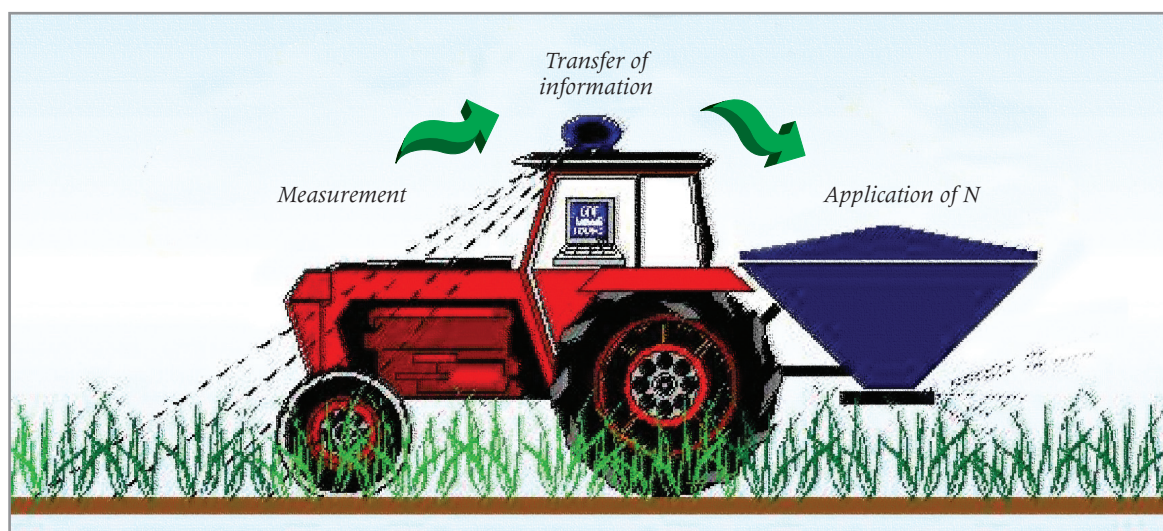
Localized management practices are not based solely on productivity or soil fertility maps. Decision making in precision agriculture can be based on data displayed on a map, or on information obtained as an action is carried out, using real-time sensors.

Sampling may take place in intervals of months or years, as in the case of soil correction. When a soil characteristic changes rapidly, the producer can measure the variability in real time and provide the necessary input immediately, without prior sampling. An example of this would be the application of nitrogen based on information from real-time sensors (**Figure 4**).

Precision agriculture is possible thanks to the development of five technologies:

1. Global positioning system (GPS)
2. Geographic information system (GIS)
3. Remote sensing
4. Variable rate technologies (sensors, controllers and others)
5. Analysis of geo-referenced data (geo-statistics, spatial econometrics, multi-factor analysis, cluster analysis and CART, among others)

This new information technology-based approach to agricultural production has been adopted in response to the demands of a competitive market, which include increased production and lower prices as well as techniques and systems that are more environmentally friendly.



**Fig. 4.** Real-time sensor for variable-rate application of nitrogen.

**Source:** Yara 2005



## ***Applications of precision agriculture in traditional cropping systems***

In traditional production systems, fields are considered as a whole. Based on average conditions of the field, actions are undertaken to correct limiting factors. In an effort to develop production systems that are more competitive and efficient, new techniques aimed at increasing and/or maintaining crop productivity of crops and lowering production costs have been adopted. Precision agriculture is a new way of managing information on crops, based on the existence of in-field spatial and temporal variability (Saravia *et al.*, in Borém *et al.* 2000).

Cigana (2003) offers some examples of the application of precision agriculture technologies. Both increased productivity and lower costs were reported in two fields, totaling 265 hectares, in the region of Planalto Medio Gaúcho, in Rio Grande del Sur, Brazil, planted in soybeans and corn. One of the fields, 132 hectares planted in corn, yielded 5,880 kg/ha, which exceeds the regional average of 4,680 kg/ha by 20%. This



figure is also 13% above the average of 5,100 kg/ha obtained with other crops on the same property, Hacienda Anna, where conventional methods were applied. On the 124 hectares planted with soybeans, the yield was 2,800 kg/ha. The average for the region was approximately 2,040 kg/ha (29% less), and that of Hacienda Anna, 2,520 kg/ha (12.5% less). According to Cigana, the cost of inputs for these crops vs. the other crops grown on the property was lower. In the field planted with corn, there was a savings of 18% in the application of fertilizers, and in the 124 hectares of soybeans, 23%.

## ***Applications in intensive agriculture: viticulture-viniculture***

In terms of intensive farming, precision agriculture has been used most in viticulture-viniculture. Grape growers in the United States, Australia and, more recently, Chile have found these techniques to be helpful in managing grapevines more efficiently.

Until recently, grape growers and winemakers did not have the tools they needed to identify the spatial variability of the vineyard and display it on a map, specifically as regards:

Until recently, grape growers and winemakers did not have the tools they needed to identify the spatial variability of the vineyard and display it on a map, specifically as regards:

- Soil characteristics (depth, moisture, nutrient content, acidity, etc.).
- Plant characteristics ( $m^2$  of leaves per  $m^2$  of soil [or leaf area index], leaf/fruit ratio, among others).

Today, precision agriculture enables grape growers to identify more precisely sub-areas for the production of high-quality, uniform grapes through the use of aerial images known as “multispectral images” obtained with special cameras and GIS technology. The images are then analyzed to produce what are known as “vegetation vigor indexes,” which include the Normalized Difference Vegetation Index (NDVI). This index is used to identify obtain a variable closely associated with the quality of the grape to be processed. The indexes are displayed on “vigor graphs” for different sectors.

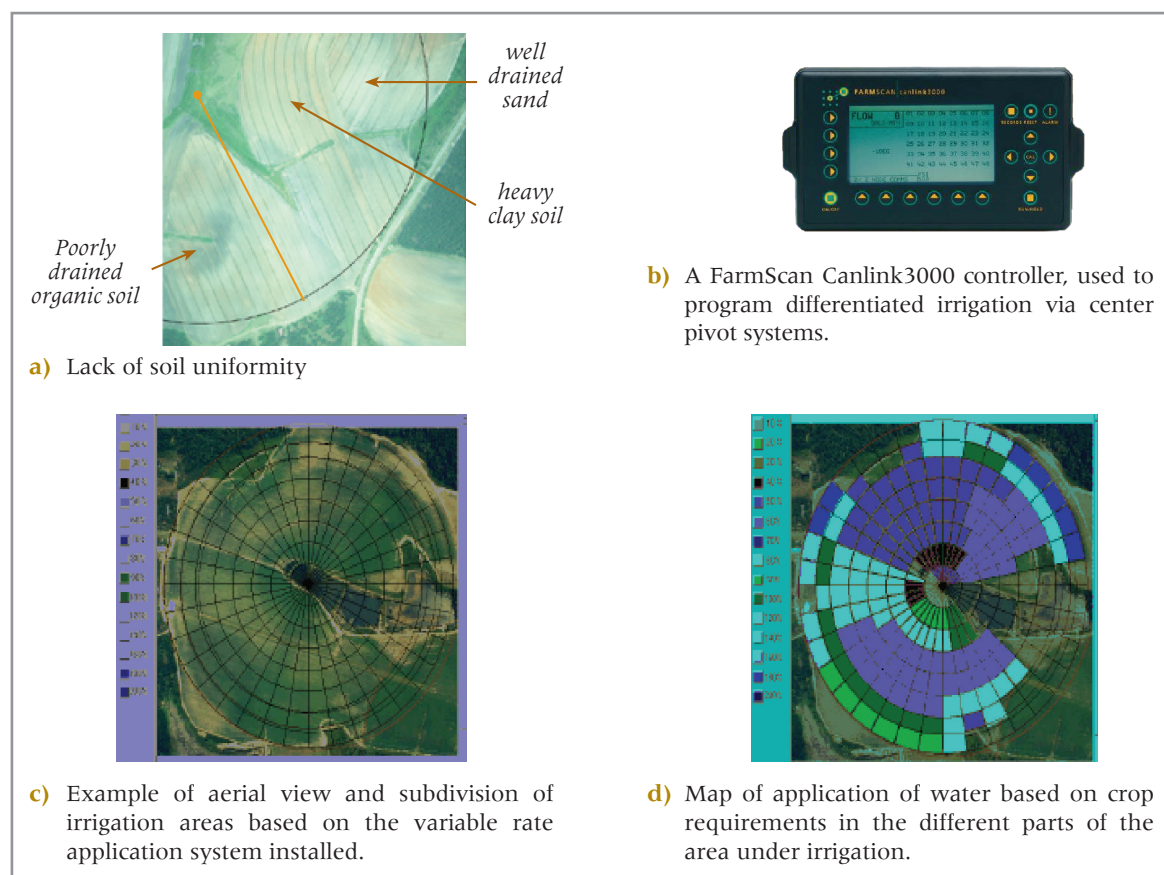
## Applications in irrigation systems

A high degree of spatial variability in terms of soil conditions translates into the inefficient application of irrigation water, a problem generally not considered in the design of new irrigation systems (sprinkler, drip and surface irrigation). Such inefficiency leads to the loss of nitrogen fertilizer and the subsequent contamination of underground aquifers via leaching (Best and Duke 2001).

The identification of uniform areas within fields and the use of computer models will lead to improved management water and more efficient use of water and nitrogen fertilizer, which in turn will protect the underground water from contamination.



Center pivot irrigation systems are the variable rate technology most commonly used to apply water and fertilizers. These systems have become an important factor in the development of agriculture because they make maximum use of a limited resource and do not over-apply or under-apply inputs to crops.



**Fig. 5.** Center pivot variable rated irrigation system.

**Source:** Best and Duke 2001

## Final thoughts

There is still work to be done if precision agriculture is to become a widely-accepted and fully viable solution for all subsectors of agriculture. Its adoption holds great potential for streamlining modern agricultural production systems because it:

- makes maximum use of the agricultural chemicals, fertilizers or corrective treatments applied to soils and crops;
- establishes clearly the correlation between spatial and/or temporal variability and among the factors associated with soil and crop development;
- determines the existence of nutrients, organic matter, acidity, water, texture, diseases/pests, weeds, etc.;
- reduces production costs and environmental contamination; and
- improves the quality of harvests.

Even though the topic of precision agriculture is relatively new, significant advances have been made that others can use, especially in the development of machinery and implements that allow for localized management based on maps. Every day, more advanced information technologies are appearing on the market, such as global positioning systems (GPS), geographic information systems (GIS), data acquisition and management systems, sensors and controllers, etc.

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## Resumen / Resumo / Résumé

### **Agricultura de precisión: Nuevas herramientas para mejorar la gestión tecnológica en la empresa agropecuaria**

**L**a agricultura de precisión es un concepto agronómico de gestión de predios o terrenos agrícolas, basado en el conocimiento e interpretación de la variabilidad espacial en el campo. Para ello requiere del uso de una serie

de tecnologías relacionadas con los sistemas de posicionamiento global (GPS), sensores, imágenes satelitales e imágenes aéreas junto con sistemas de información geográfica (SIG). Esta publicación permite compartir con los lectores una serie de conceptos y aplicaciones de estas tecnologías en distintos ámbitos, con el objeto de difundirlas, estimular su análisis y comprensión, presentar sus beneficios, complejidades y limitaciones para su uso.

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### **Agricultura de precisão: novas ferramentas para aprimorar a gestão tecnológica na empresa agropecuária**

**A**gricultura de precisão é um conceito agrônômico de gestão de edificações ou terras agrícolas, baseado no conhecimento e na interpretação da variabilidade espacial no campo. Para tanto, requer o uso de uma série

de tecnologias relacionadas com os sistemas de posicionamento global (GPS), sensores, imagens de satélite e imagens aéreas, juntamente com os sistemas de informação geográfica (SIG). Esta publicação apresenta aos leitores uma série de conceitos dessas tecnologias e sua aplicação em diferentes âmbitos com vistas a difundir-las e incentivar sua análise e compreensão, bem como apresentar seus benefícios, suas complexidades e as limitações para seu uso.

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### **Agriculture de précision : nouveaux outils pour améliorer la gestion technologique dans l'entreprise agricole**

**L'**agriculture de précision est un concept agronomique de gestion des domaines ou terrains agricoles, fondé sur la connaissance et l'interprétation de la variabilité spatiale dans la parcelle. Elle requiert l'utilisation d'une série de technologies liées aux systèmes de

positionnement mondial (GPS), aux capteurs, aux images satellitaires et aux images aériennes, conjugués aux systèmes d'informations géographiques (SIG). Le présent article vise à présenter aux lecteurs une série de concepts et d'applications de ces technologies dans divers domaines, dans le but de les faire connaître, de stimuler leur analyse et leur compréhension, et de montrer leurs avantages, leurs complexités et les limites de leur utilisation.

# Agrobiotechnology in the Americas

*Global challenges for food production*

Assefaw Tewolde, Adriana Chavarría and Eduardo Rojas<sup>1</sup>



## KEY WORDS

Agrobiotechnology  
Biotechnology products  
GMO  
Biosafety

call for more efficient types of agriculture if the human race is to grow and develop economically on a sustainable, socially acceptable footing. One area of science and technology that may be able to promote truly advanced agriculture is agrobiotechnology (Cohen 2006 and Tsotsos 2007).

Some countries have recognized the potential of this alternative and adopted agrobiotechnology as a vehicle for knowledge-based economic development, together with an appropriate regulatory framework for biosafety compatible with international standards.

The term “biotechnology” refers to “any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use” (Convention on Biological Diversity). More narrowly, it considers all the molecular technologies, such as gene manipulation and transfer, DNA typing and cloning of plants and animals (FAO 2000).

In some industrial processes, the use of biotechnology dates back centuries. It has also been used for studying the environment, medicine and the like. In the specific field of agriculture, agrobiotechnology has been seen as a tool for preserving genetic

**A** Given the growing demand for food and the steadily shrinking amount of available farmland, the world faces an ever-greater need to promote the conservation and management of genetic diversity. Agriculture is now being used as an alternative for the production of bioenergy, and at the same time, the world is facing new challenges of climate change. All these factors

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diversity, especially targeting those genetic resources that are endangered. Indeed, agrobiotechnology has provided the means to produce crops that exhibit economically important characteristics such as pest and disease resistance and higher-quality agricultural products. It has led to the development of animal-based pharmaceuticals such as bovine somatotropin (BST) and has even gone so far as to produce cloned animals. In most fields where it has been adopted to make the sector more competitive, major economic and environmental benefits have accrued in both developed and developing countries.

The question is, if agrobiotechnology has proved to be beneficial, why does it arouse so many diverging opinions? Why has it been so slow to develop and be adopted in Latin America and the Caribbean (LAC)? This article will discuss the problem areas where agrobiotechnology may be best equipped to contribute solutions. It will also describe research trends in this field in LAC, the development of genetically modified organisms (GMOs), and specific regulatory frameworks for biosafety that currently take the shape of international agreements and negotiations.

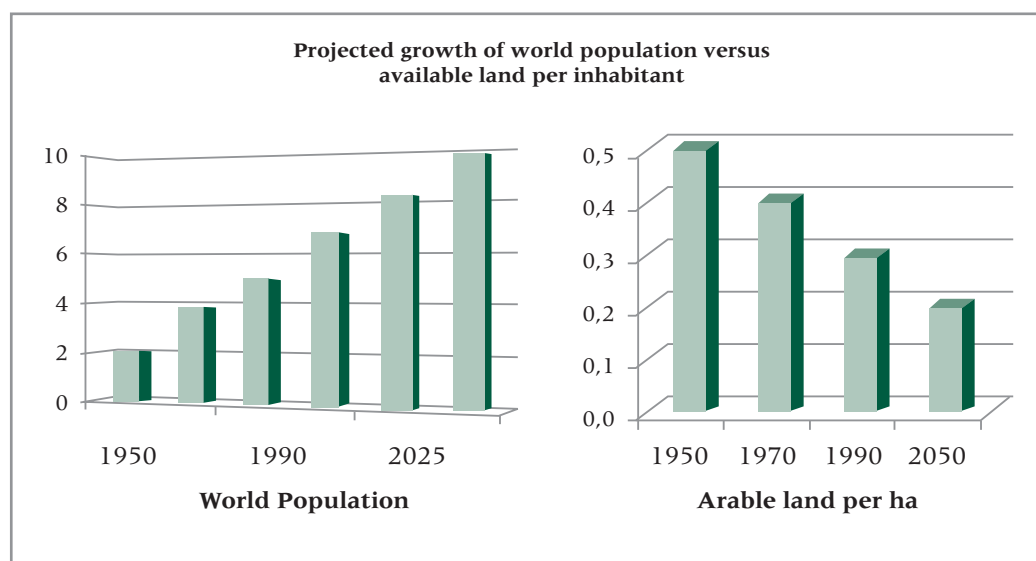
## Agrobiotechnology and world challenges

Agriculture will be expected help cushion the impact of many of the problems facing the world over the next 30 to 40 years, including:

- Population growth, expected to reach 9 billion people by 2025, most of them in developing countries (**Chart 1**).
- Loss of farmland, leaving a projected total of less than 0.2 ha per inhabitant (**Chart 1**).
- The effect of climate change on agriculture.
- The consequences of economic globalization.
- The demand for foods such as cereals will grow by 11% to 15% by 2050 (Cohen 2006, IFPRI 2004).

With the combination of all these projections, the outlook is clearly more complex. It means that the human race will need to develop technologies that yield greater productivity and more products.

Chart 1



Source: CGIAR/FAO 2003

Technologies must be both nutritious and safe, easily adapted to climate conditions such as drought or flooding, and amenable to changes in the physical and chemical qualities of soil. At the same time, new technologies will need to be environmentally friendly to ensure conservation and management of existing genetic diversity.

All these conditions and challenges clearly point to some of the biotechnological solutions that have already been accepted by the world scientific community. These include genetic improvement of orphan crops, increased tolerance to abiotic stress and acidic soil conditions, development of vaccine-producing crops, industrial crops grown on marginal lands and the promotion of bio- and phyto-medications.

**Table 1** lists various types of abiotic stress that agrobiotechnology may be able to overcome.

Molecular biotechnology also holds potential for improving agricultural production systems, with a direct impact on livestock production systems and bioenergy (Trigo 2007). Similarly, genetic mapping or sequencing of animal genomes has contributed to the development of livestock products of high enough quality to meet consumer demands (Jones and Tewolde 2006; Casas 2005).

## Biotechnology research trends and constraints in LAC

The private sector in LAC is investing very little in agrobiotechnology research. Most studies in this field are financed with public resources (Tewolde et al. 2006) to target disease resistance, genetic mapping of certain species, and improvement assisted with the use of molecular markers. Most of these studies are undertaken with the objective of making production systems more efficient, laying special emphasis on certain economically important characteristics.

**Table 2** shows the direction of public sector crop research in various countries of LAC, where the main characteristics being studied are resistance to drought, salinity, cold, diseases, fungus, bacteria, lepidoptera and coleoptera (Sampaio 2006).

The countries currently developing research activities in agrobiotechnology are Argentina, Brazil, Colombia, Cuba, Costa Rica, Guatemala, Bolivia, Chile, Peru and Venezuela. They are studying both annual and perennial crops. Nevertheless, none of these countries has biotechnology products currently on the market, with a few exceptions in countries where research is taking place in collaboration with private companies.

<b>Table 1. Types of abiotic stress potentially solved with agrobiotechnology.</b>	
<b>Facts</b>	
Drought	5000 Lt water per kg of whole rice. 70% of the word water used in agriculture.
Salinity	380 000 ha affected by high salinity.
Acidity	Affects 40% of all arable land. 380 000 ha are affected in South America alone.
Temperature	70% of total land in de Andes is used for potatoe production despite its vulnerability to cold stress.
Of the 13 billion hectares of land in the word, only around 10% is under cultivation. Added to the lost produced by pests and diseases, data suggest that more than 70% of lost potential yield was caused by abiotic stress.	

Source: CGIAR/FAO 2003

This is why the development of research activities in LAC needs to be covered by regulatory systems and intellectual property laws. According to Sampaio (2006), the countries have yet to develop comprehensive regulatory frameworks on biosafety to cover research, production, marketing, labeling and

traceability in these countries. Thus, despite efforts underway in the hemisphere to continue making new discoveries and producing new knowledge, the countries still need to develop national policies and establish regulatory frameworks for each of the components of agrobiotechnology research.

<b>Table 2. Targets of agrobiotechnology research in LAC.</b>		
<b>Characteristic</b>	<b>Crop</b>	<b>Country</b>
Drought resistance	Peanuts, soybeans, corn, rice, wheat	Brazil Colombia – CIAT Mexico – CIMMYT
Resistance to salinity	Tobacco	Argentina
Aluminum resistance	Corn, wheat	Brazil Mexico – CIMMYT
Resistance to cold	Potatoes	Bolivia
Disease resistance	Corn, sunflowers, wheat, cacao, banana, apples, grapes, rice, tomato, potatoes, papaya	Argentina Brazil Chile Colombia – CIAT Peru – CIP Venezuela Costa Rica
Fungus	Potatoes, banana, citrus, papaya, rice, sugar cane, tomato, melon, zucchini	Cuba Mexico
Bacteria	Potatoes, tomato, beans, sugar cane, papaya, passion fruit, melon, rice, banana-plantain, coffee, corn, citrus, zucchini	Argentina Brazil Chile Colombia – CIAT Peru – CIP Venezuela Costa Rica Cuba Mexico
Resistance to lepidoptera	Alfalfa, cotton, corn, soybeans, sunflower, sugar cane, cassava-manioc, potatoes, rice, coffee, pineapple, tomato, sweet potato-yams	Argentina Brazil Colombia – CIAT Peru – CIP Guatemala Costa Rica Cuba Mexico
Resistance to coleoptera	Potatoes, cotton	Argentina Brazil

*Source:* Sampaio 2006

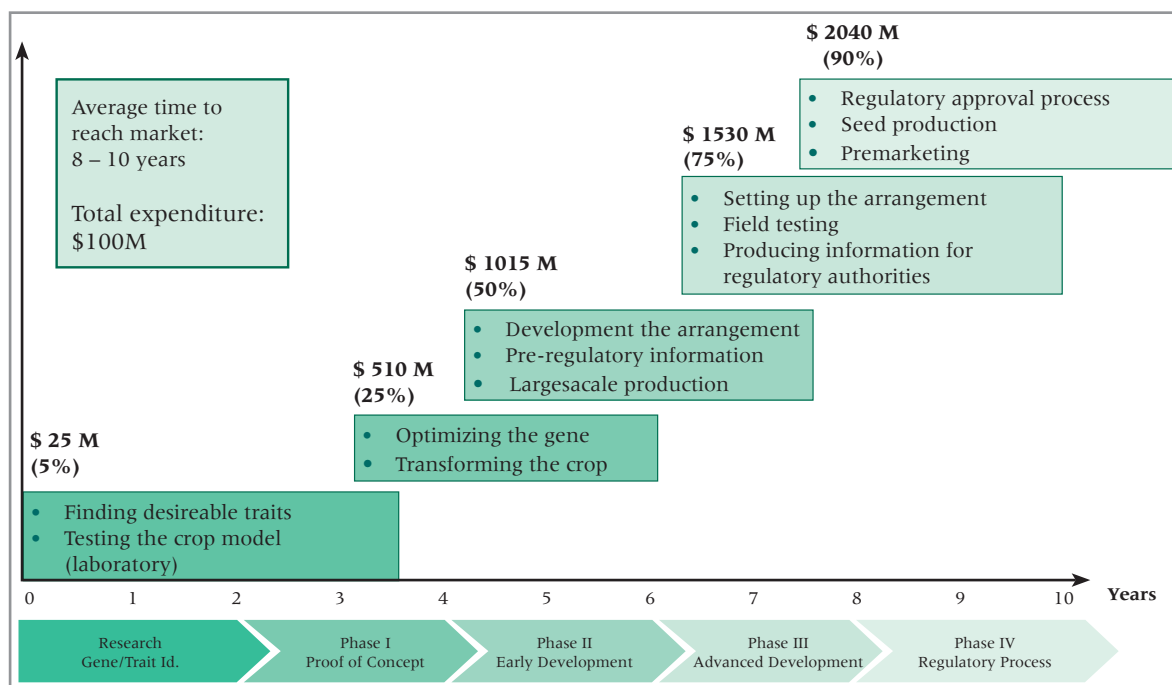


Fig. 1. Costs and timetable for the stages in developing a GMO.

Source: CGIAR/FAO 2003

**Figure 1** outlines the various steps needed in development, technology transfer and marketing of biotechnology products.

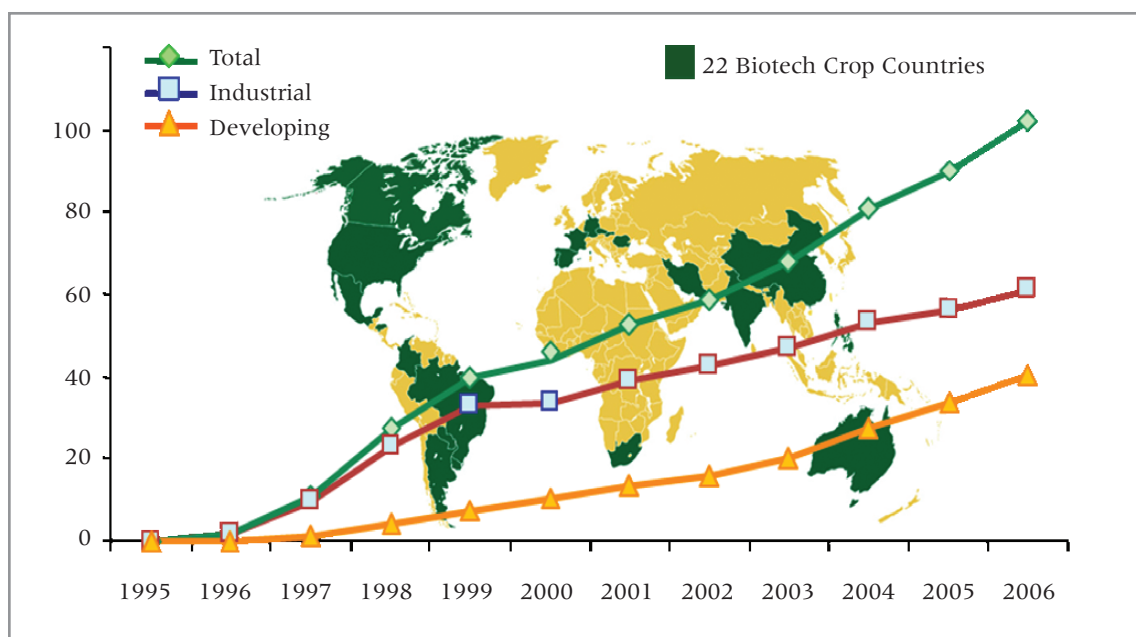
Significantly, over 10 years are needed to take a biotechnology product such as a GMO to market, at an approximate cost of over \$100 million (Tsotsos 2007). Because the countries have very limited resources available, they need to multiply their efforts at encouraging interested private companies to invest in the production of GMOs.

### Agrobiotechnology, GMOs and biosafety regulatory frameworks

Over 10 years have elapsed since agrobiotechnology crops such as corn, soybeans, cotton and canola were developed and adopted for the first time. **Figure 2** shows the growth of GMO production (ISAAA 2006). At present, agrobiotechnology has been adopted in 22 countries where more than 100 million hectares of cropland have been planted to biotechnology

products or genetically modified organisms. Of these 22 countries, nearly half (Canada, the United States, Mexico, Honduras, Brazil, Argentina, Uruguay, Paraguay, Chile, Colombia) are located in the Americas. This is why it is so important for the countries of the Americas to take a leading role, not only in technology development, but also in food production and marketing at the world level.

To date, biotechnology crops have brought economic benefit to consumers, producers, the industry and even governments by improving productivity and lessening the use of pesticides and insecticides (Traxler 2006; Trigo 2006). No scientifically proven evidence has yet shown that GMOs are having a negative impact on the environment, public health or genetic diversity (FAO 2004). Even in the centers of origin of certain species, no evidence has been found to substantiate claims of gene flow and its apparent consequences for genetic diversity. Nevertheless, more data will clearly be needed to verify the impact of each GMO that is developed or introduced in a country for direct consumption or processing.



*Fig. 2. Area planted to biotechnology crops worldwide, in millions of hectares, 1996-2006.*

*Source: ISAAA 2006*

There is no question that GMOs have been developed with close attention to regulatory frameworks. Along these lines, the international community has developed agreements such as the Cartagena Protocol on Biosafety to prevent environmental damage, threats to public health, and genetic erosion of species. Nearly all the countries of the Americas, with a few exceptions, are parties to the Protocol, which obliges them to implement standards for the development or cross-border trade of these products.

## Conclusions

As the world faces increasing difficulty to feed its people, agrobiotechnology emerges as a potential solution. It can serve as a useful production mechanism only if it is covered by effective regulatory frameworks on biosafety, currently translated into international agreements and negotiations.

Some countries of the Americas are already engaged in research in the field of agrobiotechnology. Studies have focused on certain characteristics of those plant and animal species that hold the greatest economic importance. Nevertheless, products developed by research projects in LAC are still far from winning healthy markets.

Nearly half the countries that have adopted agrobiotechnology are located in the Americas. Most of those that have failed to do so are held back primarily by the cost: it takes more than \$100 million and nearly 10 years to develop, transfer, validate and market a GMO. This is why more work is needed for building private partnerships to carry out the development of GMOs, together with a regulatory framework on biosafety consistent with international standards.



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## Resumen / Resumo / Résumé

### **Agrobiotecnología en las Américas: ante los desafíos globales para la producción de alimentos**

Uno de los principales desafíos por resolver en el mundo en los siguientes 25-30 años es determinar la forma de satisfacer la demanda creciente de alimentos que se estima será del 11% a 15% de la actual y que deberá satisfacer a cerca de 9 mil millones de habitantes con reducidas tierras agrícolas per cápita. Esto se complica aún más cuando se toma en cuenta la crisis que enfrentan los

componentes del medio ambiente, como el recurso hídrico y la tierra, además de los efectos del cambio climático. En el presente artículo se muestra este panorama y la ingerencia que ya ha tenido la agrobiotecnología como alternativa para el desarrollo y la competitividad agropecuaria de los países, junto a un marco regulatorio de bioseguridad de conformidad con los estándares internacionales. También se expone la tendencia de la agrobiotecnología en la región, sus limitantes e interés de los sectores público y privado para invertir en investigación acerca del tema.

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### **Agrobiotecnologia nas Américas: desafios globais para a produção de alimentos**

Um dos principais desafios que o mundo precisará enfrentar nos próximos 25-30 anos é saber como responder à demanda cada vez maior de alimentos, cuja previsão é de 11% a 15% da atual, e que deverá atender a cerca de 9 bilhões de habitantes com reduzidas áreas agrícolas per capita. Isso se torna ainda mais complexo quando se considera a urgência de conservar o meio ambiente, incluindo a água e a terra, além dos efeitos

que acarretam as mudanças climáticas. Este artigo apresenta o panorama da situação e a ingerência que vem tendo a agrobiotecnologia como alternativa para o desenvolvimento e a competitividade agropecuária dos países, junto com um marco regulatório de biossegurança baseado em padrões internacionais. Também aponta as tendências da agrobiotecnologia na região, seus fatores limitantes e a necessidade de complementar os esforços dos setores público e privado para investir no desenvolvimento, adoção e transferência da agrobiotecnologia.

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### **Agrobiotechnologie dans les Amériques Face aux défis mondiaux de la production alimentaire**

L'un des principaux défis qui attendent le monde au cours des 25 à 30 prochaines années consiste à trouver le moyen de satisfaire la demande alimentaire croissante qui, selon les estimations, augmentera de 11 % à 15 % par rapport à la demande actuelle et devra satisfaire quelque 9 milliards d'habitants alors que, parallèlement, la superficie des terres agricoles par habitant ira en diminuant. Le problème devient encore plus complexe lorsqu'on tient compte de l'urgence de conserver

l'environnement, notamment les ressources hydriques et la terre, sans oublier les effets du changement climatique. Le présent article brosse un tableau de la situation et montre la place prise par l'agrobiotechnologie en tant que solution de rechange pour le développement et la compétitivité agricole des pays, conjuguée à l'établissement d'un cadre réglementaire de biosécurité conforme aux normes internationales. L'article décrit également la tendance suivie par l'agrobiotechnologie dans la région, ses facteurs limitants et la nécessité de renforcer les efforts d'investissement des secteurs public et privé dans le développement, l'adoption et le transfert de l'agrobiotechnologie.

# The hidden costs of food-borne diseases

Ricardo Molins<sup>1</sup>

## KEY WORDS

Food safety  
Quality  
Foods  
Control  
Costs



## The right to food

**L**At the 1996 World Food Summit, government leaders called attention to the right to food, which, according to FAO, is “the right of everyone to have access to safe and nutritious food” (FAO n.d.), as recognized in the 1948 Universal Declaration of Human Rights (U.N. n.d.). This right is not limited to freedom from hunger, but also includes the obligation for States “to promote full enjoyment of the right of access to adequate nutrition for each individual.” Adequate nutrition, in turn, was described at the World Food Summit as “food that is adequate in quantity and quality for a healthy and active life.” Therefore, food quality (including nutritional quality and protection for consumers against fraudulent practices such as the use of false or deceptive labeling) and food safety are concepts that are rooted in the most basic rights of humanity, and are so recognized by the world community.

Governments, through the relevant institutions and agencies, are responsible for safeguarding the health of the people. This includes ensuring that enough food is available (food security) and that it is safe for human consumption. Because this requires the participation of all links in the agrifood chain, it is no easy task.

## The food safety and quality system

If the national food safety and quality system is to be effective, laws and regulations must be in place that cover production, handling, transportation, processing and distribution systems. Additionally, at the commercial level, food safety and quality systems are expected to cover the food preparation and service sectors; in other words, the system must extend from the farm or pond to the tables of consumers. This modern concept of food quality and safety assurance throughout the agrifood chain is known as “**from farm to table.**”

In addition to the legal framework, food quality and safety systems must include a mechanism for effective enforcement of relevant laws and regulations. The effectiveness of a legal framework depends on its enforceability. Therefore, national food safety and quality systems must include appropriate national laws and regulations, inspection, analytical laboratories, and management of the system. Further, it is essential that the system include proper channels for information and communication between the system and stakeholders in the agrifood chain, with a view to facilitating intersectoral dialogue and continually improving the safety and quality of food products through education, training and the understanding and adoption of good practices (FAO 2003).

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### *The contrasts: export quality or for domestic consumption?*

Due to the globalization of trade, which has had a particularly significant impact on the trade of food products, developing countries are paying more and more attention to the need to assure the safety and quality of food imports and exports. Food imports can be considered as part of the domestic food supply and, therefore, must comply with the same norms and standards set for those produced locally. Food exports, on the other hand, are subject to a regulatory regime no longer based on national laws but on international standards.

These standards, called for in the Agreement on the Application of Sanitary and Phytosanitary Measures (ASPM) of the World Trade Organization (WTO n.d.), include the Codex Alimentarius (FAO and WTO n.d.), the most important collection of standards, norms and procedural guidelines recognized by the ASPM, as well as the norms and standards of blocs of countries or trading blocs. The latter vary in terms of their severity and application by authorities in importing countries. In other cases, they are part of a new set of demands imposed on suppliers by private marketing chains, in addition to the international norms.

As a result, many developing countries which have developed systems, often equivalent to the best in the world, for fresh and processed food products for export, have only a fledgling or no system in place to control the safety or quality of food for domestic consumption.

In this context, the incentives offered by external markets to consolidate a culture of quality and safety contrast sharply with the lack or inadequacy of such incentives in domestic markets (Unnevehr and Jensen 1998). The local population is often unaware of the regulations that govern the quality and safety of foods, and does not have the wherewithal to be too selective in terms of what to buy. Both consumers and producers lack timely and accurate information on practices that can contribute to food safety. Consumers seldom have the technical and scientific knowledge they would need to differentiate between safe and contaminated food, and the safety of a product cannot be seen with the naked eye. As a matter of fact, the way consumers handle food products is one of the main

*Many developing countries which have developed systems, often equivalent to the best in the world, for fresh and processed food products for export, have only a fledgling or no system in place to control the safety or quality of food for domestic consumption.*

causes of intoxication or infection caused by food (Redmond and Griffith 2003). Given this inability of consumers to differentiate, there is no pressure placed on producing and processing firms to adopt norms or practices that will improve the safety and quality of their products (FAO 2000).

As a result, two levels of food safety and quality control co-exist:

- a) **A relatively advanced control system** which ensures compliance with international norms and standards of quality and safety applicable to food products for export.
- b) **A weak, abandoned or non-existent parallel system**, applicable to the local food supply. Ironically, it is under this system (if it exists) that the foods consumed by producers, processors and exporters themselves, as well as those in charge of developing policies and programs, politicians, their families and the rest of the population, are produced and handled.

In many countries there is a **third food safety and quality control system**, located between the two above, which applies regulations to and inspects only large- and medium-scale processors of foods marketed locally under a brand name or packaged in some way. This third level, while necessary, actually penalizes the organized industrial sector while rewarding the huge informal sector, which operates with no supervision. It is in this informal sector where most of the population obtain their food. Although this sector is very difficult to regulate, some success has been reported in improving sanitary conditions in municipal markets and food stands (FAO 2000).



### *The hidden social and economic costs of the lack of food safety and quality control*

In most cases, the limited importance many developing countries attach to controlling the safety and quality of food for domestic consumption can be attributed to:

- a) The lack of consumer organizations capable of exerting pressure on governments. In developed countries, consumer protection organizations have played a decisive role in the development of national food quality and safety control systems.
- b) National planning organizations frequently are unaware of the immense economic and social implications of food-borne diseases (FBDs) because their costs are difficult to determine or even estimate (Angulo *et al.* n.d.).
- c) It is very difficult to quantify the number of cases and to classify them in terms of type of FBD for several reasons:
  - The national health system may not have the means to diagnose, via lab tests, which etiological agent is involved in every visit to a public health facility. In other words, the country lacks an epidemiological surveillance system. As a result, cases are not reported by specific FBD (for example, salmonellosis, campylobacteriosis, etc.).
  - Physicians in private practice do not conduct a qualitative diagnosis in most cases and are not required to report cases of FBDs to public health authorities.
  - Even in countries with an efficient epidemiological surveillance system and laws that require all cases of serious FBDs to be reported, only some 10% of the people who become ill with a FBD seek medical attention (FAO 2002). This is due to the fact that those affected frequently recover in less than 48 hours. Furthermore, given the paperwork involved, physicians often fail to report such cases. An example of how data can vary greatly, for the reasons mentioned above, is the case of the United States, where the number of cases of FBDs has been estimated at between 6.5 and 33 million annually (Segerson 1999).





When the number of cases is known and it is possible to identify the etiological agent, the cost of FBDs in a country can be estimated. Thus, for example, the estimated cost of 5.4 million annual cases of FBDs in Australia is 1.2 million Australian dollars (Abelson 2006). Also, some 120 thousand cases of FBDs in New Zealand in 2000 were estimated to have cost US\$88 million (Scott et al. 2000). In the United States, the cost of 6.5-33 million cases of FBDs caused by the six bacteria most commonly involved was estimated at between US\$9.3-12.9 billion (Buzby *et al.* 1996).

These figures include medical and hospitalization costs, loss of productivity (absenteeism, poor on-job performance), as well as a complicated quantification of the economic cost of the loss of each life. The study did not address the social cost of the suffering of the sick and their families and the fact, now confirmed, that FBDs can produce short- and long-term aftereffects (leading to early death and causing chronic diseases such as Guillain-Barre syndrome, in 2-3% of the cases, arthritis, autoimmune diseases, etc.) which increase the total cost of such diseases (Busby and Roberts 1996; Lindsay 1997). The fact that an FBD, bacterial dysentery, is the main cause of infant mortality in many developing countries and can impact negatively on many children for life, is also not considered in the few existing studies on the quantification of the economic costs of FBDs (Alam *et al.* 2000).

Therefore, the common result of this “invisibility” of the economic and social cost of FBDs is the absence of a national policy on food safety and quality, and thus, of food safety as part of national development plans and budgets. This, in turn, is reflected in neglect or abandonment of the national food control system.

Therefore, it is important to develop and adapt an effective methodology for estimating the true cost of FBDs, even in the absence of a national epidemiological surveillance system. It is necessary to determine the national cost of FBDs if planners are to be able to weigh the costs and benefit for the country of investing in improvements in the national food safety program.

## *Tourism and food safety*

Every year, FBDs can have important indirect, as well as direct, effects on the economies of the countries of the Americas, which can overload already strained public health systems, generate enormous medical costs, lead to lost productivity, and yet remain “invisible” to planners and decision makers. One is the devastating impact FBDs could have on tourism, an important source of revenue for many countries.



People will not want to return to a place where they became sick, or for their friends and relatives to get sick. Tourists who are unhappy because they fell ill while on vacation can be expected to speak badly of the place they visited. For example, repeated incidences of gastroenteritis caused by Norwalk-like viruses have had a serious impact on the cruise ship industry in recent years (Undated Sea Sick, n.d.). However, on land, it is the image of the country that is damaged, since tourists usually consume the same food as the local population, which is produced and handled under equal or similar conditions, even though they appear to be “better quality.”

In many countries, water, one of the most common sources of FBDs, is no exception and must be included in any effort aimed at improving food safety in order to protect the health of local consumers and tourists (CSIRO n.d.).

## Conclusions

The economic and social cost of FBDs is probably very high in most countries of the hemisphere. If this cost were visible, or at least estimated, governments would certainly take immediate steps to lower it. Therefore, estimation of the cost of the FBDs must be given serious consideration by national authorities and regional and international organizations as a first step in tackling the safety and quality problems of food for domestic consumption.

IICA's efforts to contribute to the modernization of national food safety services should focus on food both for export and for domestic markets, with a view to ensuring that the benefits of a growing culture of quality focused on exports are extended to foods consumed locally, to the benefit of consumers throughout the Americas.

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## Resumen / Resumo / Résumé

### Enfermedades transmitidas por alimentos Invisibilidad de los costos

El derecho de cada persona al acceso a una alimentación nutritiva y sana es parte de la Declaración Universal de los Derechos Humanos. No obstante, muchos países tienen un incipiente o ningún sistema de control de calidad e inocuidad para alimentos de consumo interno, a pesar de que han diseñado estos sistemas para productos alimentarios de exportación. Otros países aplican regulaciones sólo a alimentos comercializados localmente bajo marca, pero no al vasto sector informal.

Existen diversos factores por los que muchos países del hemisferio otorgan poca importancia a este tema: a) ausencia de asociaciones fuertes

de consumidores capaces de influenciar al sector público; b) carencia de elementos de juicio o recursos económicos por parte del consumidor que le permita ser selectivo y así generar fuerzas de mercado; y c) invisibilidad del enorme costo económico y social de las enfermedades transmitidas por alimentos (ETA).

Particularmente, la estimación del costo de las ETA debe recibir seria consideración por parte de las autoridades nacionales y de los organismos regionales e internacionales, como preámbulo para enfrentar seriamente este problema. Los beneficios de una creciente cultura de calidad enfocada hacia el exterior deben extenderse también a los alimentos de consumo interno, para beneficio de los consumidores de las Américas.

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### O custo invisível das doenças transmitidas por alimentos

O direito de cada pessoa ao acesso a uma alimentação nutritiva e saudável está presente na Declaração Universal dos Direitos Humanos. Não obstante, em muitos países os sistemas de controle de qualidade e inocuidade dos alimentos de consumo interno são incipientes ou mesmo inexistentes, embora estejam organizados para produtos alimentícios de exportação. Outros países aplicam normas apenas no caso de alimentos comercializados

localmente sob marca, mas não no vasto setor informal.

São diversos os fatores pelos quais muitos países do Hemisfério atribuem pouca importância a este tema, como por exemplo: (a) falta de associações fortes de consumidores, capazes de influenciar o setor público; (b) carência de elementos de juízo ou recursos financeiros por parte do consumidor que lhe permita ser seletivo e, assim, gerar forças de mercado; e (c) invisibilidade do enorme custo econômico e social das doenças transmitidas por alimentos.

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### Les coûts invisibles des maladies transmises par les aliments

Le droit de chaque personne d'avoir accès à une alimentation nutritive et saine est inscrit dans la Déclaration universelle des droits de l'homme. Néanmoins, de nombreux pays ne disposent pas de système de contrôle de la qualité et de l'innocuité des aliments destinés à la consommation intérieure, ou ont un système embryonnaire, alors qu'ils ont conçu de tels systèmes pour les produits alimentaires d'exportation. D'autres pays ont établi des règlements qui s'appliquent seulement aux aliments commercialisés localement sous une marque, mais pas au vaste secteur informel.

Plusieurs facteurs expliquent pourquoi de nombreux pays du continent accordent peu d'importance à cette question: a) absence de

puissantes associations de consommateurs capables d'avoir une influence sur le secteur gouvernemental; b) manque de ressources économiques ou d'éléments permettant de porter un jugement chez le consommateur, ce qui l'empêche d'être sélectif et de donner ainsi naissance à des forces de marché, et c) caractère invisible de l'énorme coût économique et social des maladies transmises par les aliments (MTA). Il importe tout particulièrement que les autorités nationales et les organismes régionaux et internationaux accordent une attention réelle à l'évaluation du coût des MTA, comme premier pas en vue d'affronter sérieusement ce problème. Les bénéfices d'une culture de la qualité axée sur les produits d'exportation, qui s'impose de plus en plus, doivent s'étendre aux aliments destinés à la consommation intérieure, au profit des consommateurs des Amériques.