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Agriculture in the Twenty-first Century: Challenges and responses

An alliance for greater productivity

Science, technology and agriculture in Mesoamerica

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The relationship between research and development, as well as the use of technologies has evolved in recent decades.

This article summarizes the main ideas presented by 27 experts from the Americas at the "Ministerial Conference on Science and Technology to Increase Agricultural Productivity," held on May 10-11, 2004, in San Jose, Costa Rica. The document, which mirrors the order in which the topics were addressed, concludes with a number of comments and conclusions.

Growth and innovation: Figures tell the story

During the first plenary session, one of the speakers called attention to the important role science and technology play in increasing agricultural productivity, stating: "...technological innovation is the engine that drives the capacity of nations to meet basic human needs, strengthen their global competitiveness, and make the transition towards sustainability. Secondly, advances in information technology have contributed to greater integration of countries through communication."

An analysis of the performance of the sector over the last 40 years reveals the impact science and technology have had on agricultural development.

A study of agricultural production and productivity, and the factors contributing to same showed that between 1961 and 1980agricultural production in Mesoamerica during this period grew at an annual rate of 3.87%, surpassing the average for all of Latin America and the population growth rate, estimated at 2.8%. (See Table 1.)

In other words, during this period, per capita agricultural production rose steadily. In contrast, from 1981 to 2001, it grew at an annual rate of only 1.89%, falling below the rate of growth of the population. As a result, per capita agricultural production declined.

The data in the last two columns of Table 1 show that the downward trend experienced in Mesoamerica did not occur in other regions such as the Southern Cone and the Andean Area.

Table 1

Latin America and the Caribbean
Rates of Growth in Agricultural Production
1961-1980 and 1981-2001

	Crops		Livestock		Aggregate	
Regions	**1961-1980**	**1981-2001**	**1961-1980**	**1981-2001**	**1961-1980**	**1981-2001**
Southern Cone	**2.79**	**2.98**	**1.74**	**2.95**	**2.16**	**2.80**
Andean	**2.43**	**2.65**	**3.95**	**2.92**	**3.00**	**3.09**
Mesoamerica	**3.60**	**1.32**	**4.35**	**2.84**	**3.87**	**1.89**
Caribbean	**1.20**	**-0.71**	**2.78**	**0.77**	**1.48**	**-0.28**
Average L.A.	**2.55**	**1.57**	**3.56**	**2.38**	**2.74**	**1.89**

Source: Flavio Ávila and Evenson (2004).
Note: southern Cone: Argentina, Brazil, Chile, Paraguay and Uruguay. **Andean Area:** Bolivia, Colombia, Ecuador, Peru and Venezuela. **Mesoamerica:** Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panamá. **Caribbean:** Cuba, Dominican Republic, Haiti, Jamaica and Trinidad and Tobago.

However, data on the rate of growth in agricultural production alone do not provide a complete picture of the efficiency and competitiveness of the agricultural sector. An instrument widely used for this purpose is the Total Factor Productivity index (TFP), which measures how much of the growth in production is attributable to the impact of technological change on production, rather than to an increase in the use of inputs and services. Table 2 shows the annual rate of growth of the TFP index for several regions of Latin America during the same two periods. anteriormente.

Table 2

Latin America and the Caribbean:
Rates of Growth of Agricultural TFP Index
1961-1980 and 1981-2001

	Crops		Livestock		Aggregate		
Regions	**1961-1980**	**1981-2001**	**1961-1980**	**1981-2001**	**1961-1980**	**1981-2001**	**Promedio**
Southern Cone	**1.49**	**3.14**	**0.72**	**2.51**	**1.02**	**2.81**	**1.92**
Andean	**1.11**	**1.71**	**1.73**	**1.92**	**1.41**	**1.81**	**1.610**
Mesoamerica	**1.65**	**1.05**	**2.77**	**1.53**	**2.1**	**1.32**	**1.74**
Caribbean	**0.66**	**-0.89**	**2.60**	**2.06**	**2.03**	**0.90**	**1.47**
Average L.A.	**1.46**	**2.40**	**1.42**	**2.2**	**1.39**	**2.31**	**1.85**

Source: Flavio Ávila and Evenson (2004).

Changes in the rates of growth in the TFP index, by region and period, match closely those of agricultural production. However, in the case of the TFP index, it is clear that the agricultural sector in Mesoamerica was less able by 2001 to reduce production costs through technological change.

What happened between these two periods that impacted negatively on agricultural production and productivity? Table 3 lists some of the main economic and institutional changes which took place in Latin America in both periods.

Table 3

Latin America and the Caribbean: main economic/institutional changes 1961-1980 and 1981-2001

1961-1980	1981-2001
Dominated by public research systems (NARIs)	Decreasing importance of public sector as new actors enter system
Centralized administrative and funding system	Decision making becomes important. Administration and funding decentralized.
High level of public investment	Reduction in public investment in R&D. Private sector moves to fill void.
Significant increase in human capital	Reduction in human capital
Linear concept of innovation: Research (NARI)-Extension-Farmer. Technology as a central concept	Innovation system: Integration of research, extension and education. Knowledge is core concept.
Supply oriented	Demand oriented
Technology focused on production & productivity	Technology focused on diversifying objectives
Extension based on technology transfer	Extension based on transfer of knowledge
Products as public goods	Products as a mixture of public and private goods
Public funds allocated through a centralized monopolistic mechanism	Allocation of funds is competitive and transparent. Funding is diversified.
Protected economies	Trade liberalization. Trade agreements.
Domestic market. No demand for quality	Food quality important. Sanitary and phytosanitary issues of key importance.
Domestic prices out of line with international prices	Domestic prices in line with international prices

Given the above, the question is: Why were these reforms or changes implemented successfully in other regions, but not in Mesoamerica? Several speakers addressed this issue, each from his/her own perspective.

Using science and technology to increase production

Several studies support the existence of a positive correlation between investment in agricultural research and increased productivity in the sector.

For example, the study by Flavio Avila and Evenson shows that higher growth rates in the TFP index are associated with access to more Technical Capital (understood as investment in R&D, the educational level of the work force and the number of extension agents).

Furthermore, the authors showed that for a country to develop a healthy innovation system, it must be able to innovate on its own and to adapt technology developed elsewhere to their circumstances.

The 1961-1980 period was characterized by what is known as the "Green Revolution," one goal of which was to boost agricultural productivity through the development of new varieties, the use of fertilizers, irrigation (where needed and available) and, to a lesser extent, the application of pesticides.

The main goal of R&D in this period was to increase the productivity of the land, as well as agricultural production. Agricultural research institutions in Central America were in the development stage and capitalized on the external spillovers of the Green Revolution.

As a result of reforms carried out during the 1981-2001 period, research priorities changed. New technologies were aimed not only at increasing productivity, but also at reducing production costs, improving food quality and food security, preserving the environment, developing new market opportunities (organic production), and meeting social needs (equity).

This shift in focus also reflected a change in the forces that determined the direction of technological change. In the past, technological change was driven directly by the user. Today, as a result of globalization, the demand for innovation comes mostly from is more dependant of final consumers, via two mechanisms: product prices and consumer preferences.

In the first case, consumers' demand is reflected in higher prices that are increasingly accessible for producers who and passed on to the innovation system in the form of technology demand. The other mechanism is more subtle and is the result of public research institutions being more and more dependent on external funding sources. In this way, Cconsumers in foreign markets become both consumers and indirect donors and transmit their preferences to donors agencies who in turn passed to the research institutions through the funding mechanism (directed funds). In this way, consumers in third countries influence the research agenda in an indirect way.

In the judgment of the speakers, more must be invested in research and rural education if a reasonable and sustainable rate of agricultural development is to be obtained. Also, it is necessary to make further reforms in land tenure practices, with a view to promoting the operation of large-scale farms whose products will have greater value added.

Another aspect of technology development that emerged in the period 1980 – 2001 was natural resource conservation. Even though Latin America and the Caribbean possess a wealth of biodiversity, problems such as deforestation, pollution and the indiscriminate use of agrochemicals persist

While the situation continues to be precarious, globalization and consumer preferences have produced hopeful signs. New trends in organic agriculture, food quality, and environmentally friendly production are beginning to have an impact.

In addition to technology, the success of this trend lies in two processes: marketing (differentiation of products and penetration of niche markets) and product certification.

The role of biotechnology

The potential to ensure competitiveness and conserve the environment may come from an unexpected source: biotechnology. Biotechnology encompasses a wide range of techniques, including, but not limited to, genetic engineering.

While it is true that most advances in biotechnology are associated with the commercial cultivation of transgenic crops in 1996, they are not the only option for agriculture in Mesoamerica.

Innovation is the foundation for increasing agricultural production, productivity and competitiveness in Mesoamerica.

According to the speakers, "several research and educational institutions in the region are making good progress in important areas such as plant propagation techniques or tissue culture, the use of genetic markers, and molecular diagnosis of pests and diseases."

Three characteristics of the products of biotechnology, i.e., the transgenic revolution are:

1. *A great deal of knowledge and considerable physical and financial resources are required to produce them and place them on the market;*
2. *Their use is protected by law; and*
3. *Su producción reside básicamente en el sector privado.*

Given the above, the development of the potential of biotechnology in Mesoamerica is no easy task. The Mesoamerican countries have begun to develop legal and regulatory frameworks to deal with this new science and, in particular, Genetically Modified Organisms (GMOs).

In general, the framework is focused on legal aspects. Actions are aimed at protecting intellectual property rights and human health. In this regard, it is essential to ensure food safety, protect the environment and avoid eventual repercussions on international trade (restrictions on demand).

Another compelling issue in the GMOs controversy is to determine who benefits from them. Many organizations claim that most of the benefits have been appropriated almost exclusively by the private sector, which also makes the huge investments required to develop them.

However, recent studies presented at the conference show that, even though the products are patented, the economic benefits of the dissemination of GMOs are shared among farmers, industry, and consumers.

Improving access to S & T

Science and technology must be accessible to all potential users. This topic caught the attention of the participants and was addressed from two different perspectives: how to make science and technology more available in a given country; and how to ensure the science and technology system is more accessible, and is more utilized by final users.

It is clear that the technological gap between countries widened during the past decade as a result of economic differences and the physical capital and knowledge required to access enter into the production sector of the new technology.

Consequently, cooperation in research has become more important in bringing advances in science and technology within the reach of less developed countries. One example of such cooperation is the creation of the position of Science and Technology Advisor within the U.S. Department of State in 2000, with the objective of strengthening the role of science and technology in the country's foreign policy.

For such cooperation to exist, there must be stable institutions that can support the funding of research in the long term.

Another possible explanation as to why the reforms succeeded in the Southern Cone and Andean regions, but not in Mesoamerica and the Caribbean, was the low level of involvement (investment) of the private sector.

Some factors that may have affected its involvement were the relatively small size of the market, an agricultural sector dominated by a non-commercial farming structure, lack of appropriate enforcement of intellectual property rights, and high transaction costs.

Others were national policies and the lack of a strong agribusiness sector to add value to agricultural products.

As a result of the reforms implemented, a new paradigm for providing technical support to agriculture emerged. The concept of National Agricultural Research Systems gave way to a more complex and comprehensive one: the Innovation System.

Greater integration among research, extension services and educational institutions gave rise to what is known as Agricultural Knowledge and the Information System (AKIS). This concept is further expanded by including the sources of innovation (including farmers and foreign suppliers), and a non-linear pattern of interaction and feedback among research, development, and the uptake of technology, giving rise to the concept of national agricultural innovation systems.

In this new context, the role of the public sector in general and that of the National Agricultural Research Institutions (NARIs) also changed. These changes

Economic considerations and the institutional reforms that worked in other regions of Latin America did not produce the expected results in Mesoamerica or the Caribbean.

required a major adjustment in the role of the public sector.

This evolution occurred within the framework of the policy reforms the countries promoted in the 1980s as a result of structural adjustment programs. The initiatives focused on the reduction the size of the public sector, which ceased to intervene in the areas of seed production and marketing.

Also, marketing boards disappeared, governments provided fewer extension services and the transfer of responsibilities to the private sector began. In the interest of efficiency, many countries prepared a profile of their agricultural sectors based on the size of farms and the income of farmers. As a result, extension services were adapted to the needs of each sector.

According to the speakers, Mesoamerica must design an effective policy for innovation in agriculture which takes into consideration the characteristics of the countries, identifies opportunities for regional cooperation and forges closer relations with key trading partners.

Who should be responsible for this transfer at the present time is a key topic of discussion. Also, it is important to recall that in the past, public extension services in many countries have failed to deliver technologies to most of the rural population, which, in Mesoamerica, is the poorest segment of the population.

Other topics of discussion are: Who should provide extension services? Which is the most effective way to ensure that the results of science and technology are available and provide benefits? There are no easy answers to these questions, and there may not be a single solution for each country.

Toward a regional innovation system

Regional cooperation plays an important role in facilitating the development of science and technology in the countries. Globalization and the information revolution have significantly reduced the cost of accessing information and knowledge available in and outside the region.

The design and implementation of these policies will contribute to reducing poverty and inequality

International and regional research organizations facilitate this task by promoting partnerships with national organizations. Some countries have questioned the wisdom of basing the development of their research system and level of technological progress on their ability to imitate.

This raises an interesting question: Is it better to invest in developing the ability to innovate or in the ability to imitate? The findings of the Avila and Evenson study support the hypothesis that there is no single solution.

In other words, no system should earmark 100% of investment resources for one or the other, but rather in a combination of the two, based on the needs and capabilities of the given country.

In a complex world characterized by rapid scientific progress and new social and economic demands from the markets, there is no easy answer to this question. The countries of Mesoamerica, however, share certain attributes that would support a policy directed at strengthening regional and international cooperation in research.

Summary and conclusions

It is clear that innovation is the foundation for improving agricultural production, productivity and competitiveness in Mesoamerica. Economic considerations and the institutional reforms that worked in other regions of Latin America did not produce the expected results in Mesoamerica or the Caribbean. As a result, after 20 years of reform in the region, in the agricultural sector:

1. The rate of growth in agricultural production is below that of the population
2. There has been a significant decline in economic efficiency (competitiveness)
3. Levels of poverty and indexes of inequality have risen considerably
4. There is a greater variety of exports, but with little value added

Some of the key reasons for this poor performance are:

A. A decrease in public investment in research and extension

B. Insignificant investment on the part of the private sector

C. Declining importance of the region internationally

D. The existence of a dual structure in the agricultural sector.

Consequently, the countries of Mesoamerica have agreed on the urgent need to invest in the development of a sound innovation policy which takes into account internal and external factors such as globalization and trade liberalization, promotes the development of science and technology and addresses intellectual property rights.

This policy must address important issues such as the strategy to follow in deciding to improve local capabilities for innovation or the ability to imitate; the policy and legal framework to adopt to encourage the participation of the private sector and have access to GMOs; the promotion of public and private partnerships for research and extension; and the role of the public sector in this task.

The design and implementation of these policies will contribute to reducing poverty and inequality. In the area of technology, caution must be exercised to avoid widening the poverty gap.

Governments must ensure that small-scale farmers have access to new technologies.

In this regard, the promotion of partnerships with the public and private services will be very important. Also, the governments must provide a legal, political and economic environment conducive to the promotion of private investment, with a view to adding greater value to agricultural products and creating jobs at the local level.

Notes:

1. Mesoamerica (Panama, Costa Rica, Nicaragua, El Salvador, Honduras Guatemala and Belize) and Mexico

2. Flavio Avila A. and R. E. Evenson. 2004. Total Factor Productivity Growth in Agriculture: The role of Technological Capital, presented at the annual meeting of the IDB Board of Governors. Lima, Peru, March 25.

3. The growth rates reported in the table also include the interpretation of rates of cost reduction at constant factor prices (Avila and Evenson, p 24).