CHAPTER 3

AGRICULTURAL KNOWLEDGE AND TECHNOLOGY IN LAC AND PROSPECTS FOR SUSTAINABLE DEVELOPMENT: PLAUSIBLE SCENARIOS FOR THE REGION

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Key Messages

Drivers that originate within a given system change and impact that system. These factors may be of different types (economic, social, political and others) and are often interdependent; in other words, changes in one driver may lead to changes in others within that particular context.

The goals set by IAASTD—hunger and poverty reduction, sustainable development and food security—cannot be fully achieved in any of the scenarios considered, namely, Global Orchestration (GO), Order from Strength (OS), Life As It Is (LA), Adapting Mosaic (AM) and Techno Garden (TG). In the GO scenario, the overall level of human well-being improves, but discretional use of natural resources causes environmental problems towards the end of the period (2030). In OS, income and social inequalities increase, and the situation with regard to food security and poverty also deteriorates. In the LA scenario, almost all the indicators improve, but the problems of income disparities and environmental sustainability persist. In AM, many of the indicators for the IAASTD goals show substantial improvement, but problems arise in the areas of environmental management and food security. In TG, progress is made in connection with some of the IAASTD goals but new and previously unknown effects on the environment occur as a result of the emphasis on purely technological solutions.

Income and income inequalities in agricultural activity: Incomes increase in four scenarios (Global Orchestration, Life As It Is, Adapting Mosaic and Techno Garden) and decrease under Order from Strength. Income inequalities are reduced under AM and TG, persist under LA and increase somewhat under GO and considerably under OS.

Social inequalities: Access to education, health, security and food security, and employment is hindered considerably under OS; GO and TG pose problems in terms of access to employment; AM and LA do so in regard to food security in urban areas.

Environmental sustainability: The most serious problems arise under OS, given that it entails a reactive approach to sustainability. GO and LA also pose problems in regard to the resilience of ecosystems, but less so than OS. AM and TG produce the best results as far as sustainability is concerned, but threats persist under both these scenarios, such as the risk to shared global resources (AM) and the unexpected effects of action on the environment (TG).

Poverty in the country and in cities: With all the scenarios, poverty is reduced in rural areas, but for different reasons: under GO, LA and OS, poverty declines because the poor move to the cities; under AM and TG, because income improves. Poverty in the cities is reduced only slightly under AM; it increases somewhat under TG, LA and GO and considerably under OS.

In all the scenarios discussed, there are different challenges and prerequisites for success with AKST and agricultural production systems, especially the most vulnerable ones. Increased interaction among countries, a concern for damage to the environment, the diversification of demand on food markets and the application of new knowledge to agricultural

activity are all factors that will have to be addressed in order to ensure the successful performance of these two systems. AKST will need to generate knowledge and technologies for different social groups, looking not only at the outputs of production systems but also at their interaction with ecosystems; at the same time, agricultural production systems will need to adopt new and diversified knowledge that will enable them to produce outputs that are profitable but also socially legitimate, environmentally friendly, healthy and relevant to consumers.

Many of the scenarios provide opportunities for AKST systems as well as for the most vulnerable production systems. They tend to lessen the heterogeneity that is prevalent throughout in Latin America and the Caribbean, especially in terms of governance and development policies, which are likely to improve under some of the scenarios (Global Orchestration, Techno Garden and Adapting Mosaic); this would also be the case with investment in education. Under Order from Strength, some groups of rural producers could benefit from the emphasis on biosecurity in this scenario, and could participate in certain market niches that will open up for Latin America.

Complexity and increased trade barriers would increase the cost of agricultural activity and threaten the sustainability of small-scale agricultural undertakings. The scenarios point to the existence of different types of barriers. Under the different scenarios, as problems relating to environmental, economic and biological issues arise, trade barriers will increase in the long run, even in scenarios of greater global integration (and greater economic openness). These barriers will have to be addressed with good policies and management capabilities, as they could lead to a loss of important markets and hinder the insertion of small farmers in the economy. As far as AKST systems are concerned, opportunities could be created for the generation of appropriate mechanisms and protocols as success is achieved in regard to compliance with international laws and rules relating to those barriers.

The scenarios in which tariff barriers are reduced create opportunities and pose threats for LAC countries. The reduction of barriers works in favor of exporting countries (such as Argentina, Brazil, Chile) and could represent a threat for countries that import foodstuffs (such as El Salvador, Cuba, Dominican Republic, Jamaica, Trinidad and Tobago). Under the Techno Garden, the threat to these countries is offset by the diversification of agriculture (which represents an opportunity for these countries).

Most of the scenarios envisage many changes in the institutional structure of the region. The changes would usually involve the continuation of current favorable trends towards greater stability and consistency between policies on social development, environmental protection, food, innovation and biosecurity. The changes would occur under the same development model currently in place (except with the OS scenario). The Adapting Mosaic scenario is predicated on premise that there will be substantial changes of a different nature, i.e., in the paradigms of

agriculture (and consequently of agricultural science and technology) and in the growing power of different interest groups.

Loss of production capacity and of agricultural production, especially in the most vulnerable systems, can be expected under some of the scenarios. These losses will occur as a result of factors pertaining to the prevailing context (such as rising temperatures, extreme events or an increase in epidemics, pests and food contamination). Heavier losses can be expected in the scenarios that envisage a larger volume of trade and in situations where the capacity for prevention and elimination (or reduction) of epidemics is limited (except in the case of OS).

In the case of climate change, a small rise in temperature could lead to improved production capacity in some regions; in others, even a small change could lead to significant losses. There could also be cases in which climate phenomena could transform areas previously considered unsuitable for agriculture into good farm lands.

Agribusiness in LAC would change, under the different scenarios, through diversification and growth. To begin with, the type of commodities targeted would be diversified, especially as regards biofuels – fuels based on sugar cane, soya and palm oil – and alternative fuels designed for more fragile ecosystems (such as the semi-arid areas in several LAC countries). In the second place, under some scenarios – in a fairly small group of countries – agribusiness will start participating in markets for specialty products (based on the intrinsic characteristics of the products but also on the company's own production processes or even new products generated by biotechnology). These markets require a strong influx of knowledge and technology (in the case of specialty products) or a suitable scale of production (in the case of commodities). Small-scale producers in the Latin American and Caribbean countries will find it difficult to meet these requirements.

Significant advances would be made in formal knowledge, especially that pertaining to the facilitating technologies (biotechnology, nanotechnology) and to ecology, and interdisciplinary integration would proceed at a rapid pace (for example, between materials engineering, food technology and biology). The purpose of such integration would be to expand basic knowledge, to generate new technologies for improving quality and efficiency or to reduce production costs. If these advances, which require considerable resources, are not coordinated with AKST systems in LAC, they could become obsolete and irrelevant to the region. Considering the current situation with regard to investment in agricultural AKST – which is not only limited but also extremely diverse – in LAC, the changes represent significant threats for these systems.

In most of the scenarios (except the Adapting Mosaic), progress in formal knowledge and technological development is left up to the large transnational corporations. In other words, the region loses its ability to generate knowledge on its own, that being the most important factor of development today. The scenarios clearly show that the option of using traditional knowledge

(as opposed to formal knowledge) would not be enough to supply the demands for food, nutrition, health and environmental development of an increasingly complex world. This represents a serious threat to the region.

Scientific activity in LAC would change in terms of who the stakeholders would be (public or private sector, NGOs, transnationals) and of who would supply the resources. Under some of the scenarios, the role of the public sector in generating knowledge and technology would decline, while that of other stakeholders would increase. Throughout the history of organizations, the mission of the public sector has been to ensure that the more vulnerable social groups have access to knowledge and technology. Although there may be some question as to whether the public sector has adequately met this goal, there is no question that this is not the role of the private sector (although members of the private sector may sometimes carry out certain actions to demonstrate corporate responsibility). In addition, NGOs can hardly be expected to fulfill that role. Thus, in these scenarios, the generation of knowledge and technology in order to offset adverse social, cultural and economic conditions is not guaranteed; in fact, the gaps between different groups of agricultural producers may even widen.

In some scenarios, the most vulnerable social groups (small farmers, subsistence farmers, indigenous communities) are not included among the social groups targeted by AKST systems. In other words, while resources for AKST systems mainly benefit large- and medium-scale producers, they do not target the most vulnerable groups, thus increasing the disparities in their performance and sustainability.

The demand for AKST systems would become more diverse. AKST systems would no longer address only the productivity of agricultural production systems, but they would envisage a wide range of objectives, from enhancing the quality, biosecurity and functionality of foods to generating new materials, to developing environmental protection processes. This means there would be competition to obtain resources for different objectives; in some scenarios, this diversification would be associated with a decline in the development of appropriate technologies geared toward the most vulnerable groups.

3.1 Chapter objectives

The objective of this chapter is to answer the question:

> "How can we reduce hunger and poverty, improve rural livelihoods and facilitate equitable, environmentally, socially and economically sustainable development through the generation, access to and use of agricultural knowledge, science and technology?"

In particular, we are concerned with the Latin American and Caribbean region and its prospects for future development. These alternative forward-looking scenarios can help us develop non-prescriptive recommendations for ensuring that science and technology offer the best possible contribution to the desired development.[1]

To fulfill this objective, this chapter describes five scenarios relating to trends in agriculture (in the broad sense), agricultural production systems and the knowledge, science and technology that are associated with them. The idea is to allow for a critical assessment of the status of global ecosystems at the beginning of the current millennium.

The scenarios described are: (a) Global Orchestration, (b) Order from Strength, (c) Adapting Mosaic, (d) Techno Garden and (e) Life As It Is. The first four are based on the scenarios that were constructed for a critical evaluation of global ecosystems that was conducted in the context of the Millennium Development Goals. The fifth scenario was designed to show the future evolution of the systems of interest, their influence and their interactions, based on the current situation.

Why the scenarios?

The future is a Pandora's box for those in charge of setting medium-term policy, who need an understanding of how their particular worlds will look five or ten years from now in order to make decisions. In the present times of widespread and rapid global communications, the social, political and economic situations of societies change at a surprising pace, and societies are also changed. Understanding how such changes might influence the future of societies is a difficult task that is fraught with uncertainty.

Building scenarios is a methodology that can be used to help understand the future and thus facilitate decision making on existing policies and strategies. Scenarios are not tied to rigid mathematical formulas that can be changed over time but rather they offer a description, over the long term, of the nature of certain complex phenomena (such as those considered in this report) and of how the present leads to that future situation. They provide a model of how different natural phenomena (social, economic, environmental, technological and so on) behave and how they interact. They make it possible to manage the uncertainty that necessarily characterizes the future, by showing us *plausible* futures, i.e., descriptions of what could happen in the future, based on certain premises concerning the choices social actors make with regard to different macro variables.

[1] Proposals for accomplishing this are presented in chapters 4 and 5.

This view of plausible futures is definitely a subjective one, but it is based on a critical analysis of existing information on the past, the present, and on methodologies – including scenarios – that allow for a systematic understanding of the future (or rather, of a number of *futures*). The future *could be thus*, not it *will be thus*. The *could be* is reasonably believable here and now.

3.2 Conceptual framework

Some concepts are fundamental to the construction of the scenarios described in this chapter. They include the following:

The concept of future: Actually, the future is something that does not exist and cannot be reached, because when I think I have reached the future, I am actually arriving at the present. Thus, when we study the future, what we are actually studying are the images or perceptions that might influence the present actions of a given person or organization.

The concept of future has to do with certain basic dimensions, namely: (1) time, the perception and measurement of which, in some societies, has to do with recurring natural cycles or phenomena; accordingly, the future is considered a natural sequence following the past and the present; (2) advances in knowledge and technology which, in contemporary societies, reflects a perspective of evolution and change that is different from the aforementioned view of the future as a continuation of the past; it implies a turbulent atmosphere of constant change, one in which future studies are both more difficult and more necessary.

The question of existing influences (of the relationships between phenomena that influence the present) and of the potential appearance of new influences must also be considered. Thus, in order to understand the future, it is important to understand existing influences on the present and also potential new events. This means that the future (or futures) is uncertain to the extent that the time horizon for the analysis of the future is expanded.

The concept of the future that serves as the basis for this chapter embodies a combination of the concepts of present influences and of future uncertainty. Thus, *the future is seen as the result of the interaction between historic trends and hypothetical events.*

The prospective approach is an approach to understanding the future in which the dynamics of different types of influences (scientific-technological, social, economic, environmental) that act on social systems over time are analyzed as a basis for constructing plausible alternative futures.

The systemic approach: In systems theory, the whole (or the system) is considered a product of its interacting parts, the knowledge and study of which must always be carried out in the light of their function within the whole. Among the conceptual frameworks applied in the systemic approach, the concepts of *system*, *limits*, *hierarchy* and *systemic model* are likely to be the most useful in prospective studies such as those presented in this chapter.

As defined by Milsun (Jones, 1970), a system is a set of parts or interactive components that are of interest to the researcher. For the purposes of this chapter, which systems are of interest to us?

The very question that drives this entire evaluation provides the clues for identifying the systems to be considered. The question refers to systems of agricultural knowledge, science and technology, as well as to systems that play a role in sustainable development, especially in the rural environment. The question also refers explicitly to the relationships between these systems, as it raises the issue of how one contributes to the results of the other.

What are the limits of the systems to be analyzed? In this chapter, limits are defined as follows:

(a) in the case of agricultural knowledge, science and technology systems (AKST), they include the systems known as traditional and local knowledge systems, i.e., the dynamic body of knowledge and practices accumulated by traditional communities and by agricultural production systems, resulting from their interaction with nature and their agricultural activities; they also include formal science and technology systems or, to be more precise, research and development (R&D) geared towards the generation of technology and knowledge for agricultural production systems;

(b) in the case of systems involving sustainable development, the question underlying this evaluation refers to agricultural production systems, given that the R&D contribution to sustainable development that is implicit in the question can only arise from its impact on these systems.

Not only do these two systems interact with each other, they are also influenced by other systems of a higher order, that is, the so-called *macro-context* or simply *context*, which involves all the different types of influences that are not generated within these R&D systems and agricultural production systems.

The complexity of systems is simplified in the models used to represent them. An overall model representing the question underlying this evaluation (and this chapter) is shown in Figure 1.

[Insert Figure 1: Model of relationships between systems of interest]

3.3 Methodology

The first step in the process of constructing scenarios was to develop a model to represent the relationships between the systems of interest (R&D systems, agricultural production systems, and the context thereof), in more detailed fashion than that shown in Figure 1. Although the analysis must take into account the general model shown in Figure 1, that model is too general to include the construction of scenarios.

We therefore used the variables and the model that had been constructed recently for another future study. The other study was aimed at understanding changes in the context of R&D systems and how the changes would affect the performance of those systems over a ten-year period (to 2015) in six Latin American countries (Castro et al, 2005; Lima et al, 2005; Santamaría et al, 2005).

Thus, for the variables used to describe R&D systems and their context, we took into account the same ones used in the other study. For the variables that describe agricultural production systems, we identified the relevant variables through a process of collective creation and bibliographic review. All the variables considered in the chapter are shown in Table 1.

We then studied the relationship between the variables with the help of a cross-impact matrix. This matrix allows for an analysis to be made of the direct relationship between each pair of variables, in terms of the intensity, nature and direction of the interaction. This analysis was used to construct the relationships model shown in Figure 2.

On the basis of this model, the variables considered to be critical factors for understanding the future in the scenarios were selected. These variables are: demands and focus of R&D, appropriate technologies for agricultural production systems, incorporation of knowledge into agricultural production systems, available resources for agricultural production systems, performance of agricultural development systems, income inequality, social inequality, urban food security, environmental sustainability in agriculture. The last four critical factors describe the results of the interaction between the context and the two systems of interest (R&D and production). Submodels were developed for each critical factor, emphasizing the direct relationships between these and other variables, based on the model shown in Figure 2. Some examples of submodels for the four macro-variables of results (income inequality, social inequality, urban food security and environmental sustainability in agriculture) are shown in Figures 3 to 6.

[Insert Figures 3 to 6]

Based on these models, the scenarios were developed, using the morphological analysis matrix tool, in which plausible states of the variables are considered on the time horizon being studied. Five scenarios for two time periods (2007-2015, 2016-2030) were constructed. These scenarios are discussed below.

3.4 Scenarios: AKST and Prospects for Sustainable Development in LAC (2007-2030)

The five scenarios are described below. Table 2 shows a comparison between those scenarios and the current situation with regard to selected indicators of the variables used in this study of the future.

[Insert Table 2: Selected indicators: current situation and situation under the five scenarios]

3.4.1 Global Orchestration

2007-2015

Context of AKST and agricultural production

The world and LAC are moving towards the total elimination of barriers – except health barriers – to international trade in agricultural products.

This means that competition between countries increases as they vie for markets on the basis of price or product differentiation. The LAC countries that are already well established in commodities markets (Argentina, Brazil, Chile, Colombia, Ecuador, Mexico and others) are trying to enter the more dynamic markets (United States, China, India) and the market for differentiated products, with some success.

The diversity of consumer demand for differentiated foodstuffs in terms of flavor, appearance, nutritional content, nutraceutic properties, health concerns and other considerations has increased throughout the world. In many countries, consumers require certification of the quality of food processing, in particular, of the absence of agrotoxins, child labor, genetically modified organisms and animal suffering, to name a few. There is also a heightened concern for tracing the origin of products. As the LAC population becomes better educated – and thus has increased access to information on foods – consumers are becoming more demanding.

During the early years in most of the region, there is no increase in the frequency or severity of epidemics, thanks to incentives that encourage the use of good practices in production systems management and the development of the region's capacity and willingness to cooperate in preventing new epidemics.

In some parts of the region, significant changes have occurred in land use patterns – for example, large areas are devoted to single-crop oilseed plantations for biofuel production – which could facilitate the appearance of new epidemics. Similarly, in areas that have already been seriously affected by early signs of climate change (floods, drought, heat waves), no adaptation policies have been planned, and thus the conditions are in place for further outbreaks.

Temperatures are rising at the rate of 0.22ºC to 0.24ºC per decade, and extreme phenomena are more frequent. The impact on agriculture and systems has been significant, although it varies according to each country's capacity for adaptation and mitigation.

Decision makers and society at large (especially in LAC) have not shown much concern over these changes.

Some countries are establishing policies on social development, innovation, environmental matters and biosecurity that are consistent and in line with the overall objectives of economic development, steadily improving their capacity to manage these policies. Others still follow policies that are neither clear nor forward looking, and they also have a poor management structure. In general, however, compared with the situation that prevailed at the beginning of the period, governance in the countries has improved by the end of the period.

Education is considered a factor that influences a country's competitiveness. Accordingly, thanks to an increase in the generation of wealth, governments are investing heavily in formal education at both the basic and the post-graduate levels. Countries with less capacity are trying to ensure that their citizens at least receive a good basic and secondary education.

The players in production systems are also being provided with educational services, in parallel fashion, by private educational institutions which are gradually improving their performance, as well as by some of the large agricultural companies in different locations or countries. This is the case even at the post-graduate level.

The rich countries are making substantial investments in the development of new technologies (including nanotechnology) as well as biotechnology and informatics. Only a few LAC countries are in a position to make significant progress in knowledge relating to agricultural systems and agriculture and even less so, in the new technologies.

Both in other regions and in LAC as a whole, the value of traditional knowledge is only recognized by a few large private companies which want this knowledge in order to create new products (for example, plant-based pharmaceuticals or insecticides) that are used intensively in agricultural production systems.

AKST systems

At the beginning of this period, public AKST organizations define as priority technologies those which make it possible to: (a) increase productivity, (b) reduce production costs, (c) improve the quality of agricultural products, (d) increase food security, (e) improve the quality of processes in production chains, (f) improve the income of agricultural producers, (g) increase the competitiveness of production chains, (h) generate exportable surpluses, (i) improve the nutritional profile of urban and rural populations, (j) ensure environmental sustainability of agricultural systems, (k) develop mechanisms and conditions for promoting the production of agricultural goods and services with a high value added and (i) expand the portfolio of agriculture-based products, including non-food products. This last priority of AKST has made it possible to create in LAC (in some countries, such as Brazil, Mexico, Argentina, but not in all) a fairly significant degree of economy of non-renewable energy sources thanks to the development of biofuels (including ethanol, biodiesel, biogas).

The social groups targeted by AKST range from large- and medium-scale traditional producers, end users, agroindustrialists and policymakers, on the one hand, and business people on the other. Indigenous communities and subsistence farmers are not really relevant to AKST organizations.

The capacity to incorporate advances in formal knowledge to the generation of technology varies from country to country. Most LAC countries have only limited capacity for generation and therefore focus on adapting or even importing technology (when that is possible). Argentina, Brazil and Mexico have made substantial investments in biotechnology; this, along with their

considerable investments in nanotechnology, has enabled them to make some progress in applying these sciences to agriculture. Traditional knowledge plays a part only in certain specific initiatives.

Some LAC countries are working to ensure that resources are available for public agricultural AKST. Resources are also available from a number of international sources linked to countries, communities within countries, and international institutes.

The private system is the largest investor in research on economically profitable production and is working to expand the portfolio of products. This effort is occasionally shared with the public sector.

In the LAC countries that have public AKST institutions, the public and private sectors seem be pursuing different objectives. This difference is a result of private AKST companies receiving a return on their investments as legislation has been enacted to protect knowledge.

Most public AKST systems will be working primarily on the following agricultural products: grains, vegetables and spices, tropical fruits, livestock products and fisheries. Other countries will be focusing mainly on agriculture and other livestock species, as well as medicinal plants and cosmetics.

Technologies generated by AKST systems, whether public or private, are geared more towards intensive agriculture, large- and medium-scale products and agroindustry. Many technologies are also designed to ensure environmental protection and conservation, especially in countries with a broad biodiversity (and threats to it) or with environments that are hostile to human life (such as semi-arid or arid regions), as in Brazil, Peru, Ecuador and Mexico. While the technologies generated are appropriate to such conditions, they are not aimed at more vulnerable social groups, including small-scale or subsistence farmers and indigenous communities.

Agricultural production systems

In this scenario, there will be opportunities for increased incorporation of knowledge into agriculture, given that there will be investments in education will increase, resources will be available for agricultural activities, borders and markets will be opened up, and companies will be promoting trade in both directions. This will be a result, firstly, of the promotion of new inputs to improve productivity and secondly, of the implementation and verification of practices designed to ensure compliance with quality standards.

The large production systems provide commodities for the external market, but they also supply differentiated products for a large domestic market in LAC. Quite a sizeable number of small farmers are inserted in large production chains, such as the poultry meat chain, which although highly fragmented is efficiently coordinated. Others participate in market niches in their own countries or in wealthier countries. But the great majority of vulnerable and subsistence farmers are still left out.

The opening up of markets and borders creates a climate that fosters investment in agriculture. Access to natural resources (water, soil) is not a problem except in the most vulnerable production systems. Access to knowledge has increased.

The large agricultural corporations that apply modern production and management techniques are very efficient and produce high-quality products, thus achieving greater competitiveness. Small-scale producers who participate in large chains are usually successful as well; those who operate more independently in specific market niches sometimes do not obtain good results (efficacy is crucial for them).

Nevertheless, a significant share of production units are left out of those systems because the markets are too big for them, they are not able to meet quality standards established by the production systems (such as traceability and food safety), and they do not have access to appropriate technology. In addition, they are vulnerable to climate change, which although incipient still has a considerable impact.

Results of interaction between the systems

National and transnational corporations are consolidating their control over supply chains and markets. Some production units that operate in a better ecological and economic environment have managed to organize within those environments and thus improve their income.

In some countries, food imports compete with local food production systems, and this has a disastrous effect on small- and medium-scale production units. Those who are displaced leave farming and instead engage in small-scale, non-specialized services either in rural areas or in nearby urban centers. All this fosters inequalities in agricultural income. This occurs to different degrees in different LAC countries.

At the end of this period, there is still a considerable degree of social inequality, as evidenced in differences in access to employment, food security, education and health among different social groups (large producers, small family producers, agricultural wage-earners, subsistence farmers). At the beginning of the period, inequalities in access for some of the vulnerable groups, such as small-scale family producers and wage-earners, have been reduced considerably. This is a continuation of the trend that started during the 1990s, which was also reinforced by an improvement in overall prosperity during the period. The situation also varies from country to country in LAC. In a small number of countries, thanks to public policies and management capacity for regulation and enforcement of food quality standards, the urban poor now also have access to healthy food.

In countries that depend heavily on food imports and have lower per capita income rates (such as Nicaragua, Haiti, Honduras, Ecuador and Jamaica), the prices of these products have risen, causing food security problems. In the poorest countries of the region, where economic efficiency is low, environmental sustainability is not a concern for production systems, except in some that are highly domestic, traditional or indigenous. There is continuing deforestation, intensive use of

fertilizers and herbicides, expansion of arable lands and poor soil and water management. The replacement of native flora by farming without taking corrective action is causing a loss of biodiversity. A few countries are trying to ensure that increases in productivity go hand-in-hand with environmentally friendly technologies.

2016-2030

Context of AKST systems and agricultural production

Most trade barriers, except sanitary measures, have disappeared.

The trend towards increased competition between countries is accentuated even more during this period. The intense race to develop new agricultural products containing a high degree of technology means that commodities no longer play such an important role on the world market. The great majority of markets consume products that have some value added, many of which are totally synthesized in laboratories or generated by microorganisms. In many cases, commodities are merely the raw material for such products. Commodities are a primary source of livelihood for a few communities in LAC which have kept their identity and their rituals.

In addition to the concerns about food quality and food security which characterized the previous period, consumers now – almost without exception, given that the world population has a much higher educational level than at the beginning of the century – demand information about genetic manipulation and nanotechnologies incorporated into foodstuffs. Governments are beginning to apply regulations concerning these technologies and implement procedures for evaluating foodstuffs or agriculture-based non-food products are beginning to be implemented by the governments.

Epidemics and epizootics are increasing in frequency and severity owing to the cumulative effect of poor management of ecosystems, the introduction of new pests, failure to take action to adapt and mitigate the phenomena associated with climate change and drastic changes in land-use patterns and technology. The quality of export products is strictly monitored, and similar controls are applied to foodstuffs sold on domestic markets.

Climate change is a continuing concern, but shows signs of becoming serious when temperatures rise at the rate of 0.28ºC to 0.30ºC per decade, and the probability of extreme phenomena is equal to or greater than 0.6. LAC has improved its capacity for adaptation and mitigation, and this capacity is further increased towards the end of the period.

Governments are worried about the growing power of large transnational companies and are ill prepared to deal with the control they hold over technological development. Traditional innovation policies have become inadequate, since the State is no longer the main player in the promotion of AKST activities. Moreover, problems have also arisen in the areas of social development (e.g., loss of jobs as a result of constant technological modernization) and the environment (e.g., unexpected consequences of involuntary swallowing of nano-particles suspended in the air) and with the excessive control of transnational corporations over the lives of ordinary citizens. All of

these situations make it necessary for governments to revamp their institutions. Events relating to global climate change call for the implementation of new and vigorous policies designed to protect the environment and adapt agricultural production systems.

The governments of the more developed countries in the region devote a significant part of their tax revenues to an unemployment insurance system. These governments also offer incentives to corporations to persuade them not to terminate their employees on account of technological changes but rather to retrain them so that they can operate the technologies that have been adopted. By 2025, the governments have set a goal of gradually shortening the work week to three days within the next decade.

Most of the countries in the region have acceptable regulations and standards and enforce them adequately. This translates into a reasonable level of efficiency in production systems, products and services, and these meet the needs of users. However, neither the systems nor the majority of products, by-products and waste are environmentally sustainable, and this has a negative impact on the environment.

During the period, there has been a substantial improvement in overall stability and consistency between social, environmental and foreign trade policies in most of the LAC countries.

Stakeholders in the production systems responsible for public education have achieved a high enough educational level to create a critical mass of individuals who are qualified to compete internationally. Strategic partnerships between companies and centers of excellence, both national and international, are helping to improve the quality of public education at all levels.

Rich countries are making great progress in biotechnology and nanotechnology. During the second half of the period, significant advances are made in understanding the systemic impact of genetic manipulation. This allows for greater efficiency in the use of such techniques and the reduction of their negative impact on the environment. Biotechnology has become the technological basis for genetic improvement processes, and conventional processes have been abandoned. Nanotechnology is beginning to produce intelligent systems for monitoring plantations and herds through DNA-based nanoelectronic sensors. The two disciplines are being integrated to develop environmental remediation systems, but these technologies have not yet been fully developed. Biotechnology has also been used successfully to develop plant-based biomass for use by agroindustry, producers and consumers. In addition, alternative energy solutions are beginning to be marketed (aeolic, photovoltaic, hydrogen); some of these are cheaper than biofuels and could potentially overtake them on the market.

These advances are usually made by large transnational corporations that export their know-how to less developed countries. Agriculture is no longer a site-specific activity.

AKST Systems

As far as R&D is concerned, the division of labor between the public and private sectors has increased in the few countries that still have public research institutes. Public institutes follow a research agenda directed at the poor strata of consumers and rural producers.

The private transnational corporations that control technological development have expanded their operations throughout the world and are focusing their research mainly on technologies that can be applied over the short term. However, they also maintain a portfolio of basic science projects aimed at developing new applications for biotechnology, nanotechnology and combinations thereof, given that profitable applications based on knowledge generated by these initiatives can be obtained more quickly; in other words, the time span between the discovery and application of basic knowledge has shortened.

Public AKST organizations that are still active in LAC have become more and more dependent on the basic knowledge generated by transnational corporations.

In LAC, transnational corporations also play a predominant role in AKST. That means that they have no difficulty incorporating advances in formal knowledge; in fact, the very process of development entails the adoption of the knowledge in question, since these companies can use qualified scientists anywhere in the world.

The large companies do not “pinch pennies” on AKST efforts, given that they must keep abreast of technological innovations in agriculture if they are to win the daily battle to keep ahead of their competitors in the technology market.

Governments continue to provide financial resources for the development of technologies targeting the poor. Transnational corporations also offer lines of financing for that purpose so as to enhance their public image.

Public organizations, whether universities focusing on the basic sciences or institutes conducting applied research, have few if any opportunities for technological development. The only research conducted by public institutions is that which is directed at vulnerable groups and at agricultural products designed for “social” purposes.

AKST is quite successful in developing products that are highly attractive to consumers around the world. There is a huge and constantly changing supply of products of many different types to satisfy a wide variety of tastes – “something for everyone”. Companies are also developing technologies for everyone in the production chain, from suppliers of inputs to distributors.

These products are developed efficiently, but efficacy is more of a problem because markets and consumers are constantly demanding new features in the products they use (in other words, the efficacy of a product is ephemeral).

The technologies that have been developed are appropriate for large corporations that are competing on the market for farm-based products (but not necessarily agricultural products in the traditional sense of the term) and products designed for environmental protection and remediation. Some low-intensity products are also being developed for traditional agricultural

production systems; these take environmental impact into account and allow for mitigation and adaptation to climate change.

Agricultural production systems

In this scenario, given the increased investment in education, greater availability of resources for agricultural activity and greater openness of borders and markets, the conditions are right for increased incorporation of knowledge in agriculture through the incorporation of inputs or compliance with regulations and quality standards. The process that began during the previous period continues.

In many LAC countries, this activity is directed towards external markets, especially in the larger countries (which, however, also have strong domestic markets).

A reasonable percentage of small farmers have managed to insert themselves into the markets, thanks to their better educational level, but many have been displaced from their rural activities and have moved to the cities.

The countries have sufficient resources, which vary according to their size, their economic activity and their intellectual and technological capabilities. Nevertheless, the transnational corporations hold monopolistic control over natural resources for agricultural activity (for example, water and arable land).

The large agriculture-based corporations are constantly competing with each other, similarly to the AKST companies. In other words, they always need new products and innovative products in order to please their markets. Although their products are based on agriculture, they also include a substantial component of biotechnology and nanotechnology. Thus, for example, there are fiber crops (monitored by nano-systems) that have thermodynamic properties and microorganisms that remove pollutants from the environment. Large areas of commodity crops have been mechanized and automated as inputs for these corporations.

These large corporations have often integrated all the processes involved in agricultural production and production of inputs; in other cases, they outsource agricultural production. Highly competitive production chains of regional scope have been strengthened, and they focus on specialized and differentiated products to meet social demands for greater cultural diversity and preservation of the identity of ethnic groups. These corporations operate at a high level of performance (efficiency and efficacy). They invest considerable resources in their activities, owing to the intense competition which means it is very easy to lose their position on the market.

Results of interaction between the systems

The opening up of markets and borders creates a favorable environment for investment in agriculture. National and transnational corporations are consolidating their control over production chains and markets. More production units have succeeded in operating within this environment and improve their income. Free imports of foods, monopolistic control of natural resources and the intensification of climate change have put small farmers out of the game. All this has

increased income inequalities. On the other hand, more resources are invested in education, so that a large mass of the rural population of displaced farmers can be retrained as skilled workers for the corporations. Partly as a result of these policies, the proportion of poor in the Latin American population has been considerably reduced.

In the atmosphere of economic growth which characterizes this period, access to education, health and food security has improved for different social groups. Unskilled workers still find it difficult to get jobs. The government intervenes by providing food, housing and transport for the unemployed. In the different societies, the value attributed to work has changed. There is a growing market for leisure products.

The urban areas in LAC have no problem with food security. As far as food safety is concerned, the main sources of pollutants are monitored by sophisticated sanitary surveillance systems.

At the beginning of this period, the environmental sustainability of production systems has become a priority issue, particularly in countries that are more vulnerable to environmental disasters caused by climate change. The implications of climate change for the environmental sustainability of production systems is a serious concern. During this period, environmental sustainability in agriculture has also been affected by intense competition between markets which demand more and more products based on natural resources. Intensive agriculture reduces the resilience of many ecosystems and makes it difficult to maintain the efficiency of agricultural production systems over the long term.

3.4.2 Order from Strength

2007

Context of AKST and agricultural production systems

International trade in agricultural products in the region is governed by tariff and non-tariff barriers, the latter being aimed at reducing threats of bioterrorism. The possibility of evolving towards a free-trade system is remote.

The capacity of less developed countries to invest in technological innovation for agricultural production systems is declining; as a result, they are not able to compete on markets for differentiated agricultural products. The best they can do is continue exporting commodities under the increasingly difficult conditions created by the barriers that are in place.

Consumers in the richer countries inside and outside the region demand high standards of quality, safety, functionality and environmentally friendly production methods for both food and non-food products. It is becoming more and more difficult for poor countries to meet all these demands. On the other hand, some special markets are highly valued (e.g., products from the Amazon forest, the Chaco region in Paraguay, the salt desert of Bolivia or the Patagonia region).

Domestic markets in LAC are mainly comprised of low-income consumers who demand food at low prices.

Despite the massive use of pesticides throughout the region, serious new epidemics are still breaking out, and they are aggravated in some countries by changes in land use, climate change and the failure to take corrective action.

Temperatures are rising and extreme events are becoming more frequent. Most countries of the region do not perceive the threat of climate change and thus do not see the need to direct agricultural R&D towards mitigating that threat. Social organizations that issue warnings about what is to come find the authorities unreceptive to their message. Moreover, the capacity of most countries to take mitigation and adaptation measures is limited. Such action is not a priority for most countries.

At the beginning of the period, some LAC countries have been erratic in the measures taken to foster technological innovation, social development, environmental protection and biosecurity. At the end of the period, owing to their relations with rich countries – and their dependence on external resources – the countries have begun to develop more stable biosecurity policies that follow protocols imported from rich countries. Implementation of those policies is fully subsidized by the rich countries. Most countries are not following these policies consistently, and the ones that depend heavily on imports are even less consistent.

Policy management has also been uneven, but because of the rich countries' preoccupation with terrorism since the middle of the period, there has been a slow transition towards establishing and enforcing regulations and quality standards; these are always aimed at reducing threats through the food supply or agricultural products. The governments initially, and the transnationals at the of the period, are responsible for managing sanitary standards and anti-terrorism measures. Despite their power, the transnationals have only been able to enforce controls in the larger cities.

Public education, especially in the poorer countries, does not produce good results. Likewise, the career options and courses offered by private education are often also inadequate.

The rich countries are striving to ensure that science makes it possible to avoid biological, physical or chemical threats from poor countries; both the public and the private sectors are investing heavily in the development of new technologies (such as nanotechnology and biotechnology). Most of the poor countries in LAC have so many basic needs and such poor educational levels that the development of science is limited. These countries generally do not assign a high value to traditional knowledge.

AKST systems

In the few LAC countries that have a capacity for technological innovation, most efforts and resources are channeled towards biosecurity. The larger countries – many of which belong to economic blocs – have established sanitary barriers to food imports, but these have not changed the focus of AKST. Given the scarcity of economic resources in the region, R&D efforts are largely aimed at securing the food supply and achieving economic efficiency; neither the public

nor the private sector assign priority to the sustainability of products and processes and their impact on the environment.

The capacity to incorporate advances in formal knowledge into agriculture varies from country to country. Some (such as Argentina, Brazil and Mexico) apply advances in biotechnology and nanotechnology to agribusiness; others simply adapt or import technologies. The few countries with the capacity to generate technologies do not include traditional knowledge in that effort.

There has also been a loss of management personnel and capability in the public R&D system; some staff are migrating towards other activities or moving abroad or being hired by transnational corporations. The public R&D organizations find it difficult to set their course, define priorities and, in particular, to coordinate the overall research effort. At the end of this period, there is a large gap between the scientific and technological capacities of LAC countries and those of developed countries (such as Japan, Germany and the United States). In certain strategic areas of application, some countries in the region are beginning to import technology from the rich countries.

Owing to the scarcity of financial resources, most governments in the region are cutting back on public investment in science, technology and education. The available international financial resources are being allocated mainly for biological security projects, with donor organizations retaining ownership of the protocols, patents and genes generated by such efforts.

Throughout LAC, many public organizations are allowing the transnational corporations to take their place. In some countries, public organizations still generate knowledge and technology in certain production-related areas that are of no interest to private research organizations. For example, they conduct pre-technology research on maize breeding (i.e., intermediate products for the development of cultivars as inputs for technology products that will be the end products of the process; Castro et al, 2006). They also conduct basic research that is not attractive to the private sector.

Because of their many limitations, public R&D organizations have not been able to develop technology products that meet the demands of their clients and users, be they transnational or national private organizations. The technologies that are generated are never geared toward the most vulnerable social groups.

Agricultural production systems

The lack of investment in education, the decline in resources for agriculture and the failure to open up borders and markets have created conditions that discourage the incorporation of knowledge into agriculture. In a few cases, and only within corporate circles, some knowledge on inputs and machinery that improve productivity is being adopted. Exporters and certification companies will also require the implementation and verification of certain practices to comply with market requirements, and company partners (medium- and small-scale producers) will need to incorporate certain complex know-how relating to standards for products and processes.

Trade barriers limit agricultural markets for the LAC countries. Only a few countries export commodities to rich countries, and this entails high costs for product certification aimed at preventing biological threats. A small number of countries and organizations have an opportunity to enter the “Latin American” or “Amazonian” markets; this always requires guarantees that the products offered are safe. At the end of this period, a very small specialized market is beginning to open up for products from traditional systems.

The LAC domestic market is divided into two segments: (1) high-income consumers, a shrinking segment of which requires goods similar to those of consumers in the richer countries, and (2) poor consumers, a growing segment of which is mainly concerned with price. In many countries, the only market is that of poor consumers, and the demand for imports (mainly agricultural, and especially foods) is rising.

External markets, high-income markets and some of the poor domestic markets are supplied by large technically sophisticated production systems. Niche markets are supplied by small-scale production systems that have incorporated biosecurity technologies.

The poorer domestic markets are also supplied by production systems that have not adopted many technologies, are not involved in production chains and have little or no concern for biosecurity. This means that a significant part of the population of these countries is consuming contaminated foods.

The players in production systems are only rarely organized into stable associations. This is a reflection of their poor capacity to manage resources, their weak position on the market and the poor performance of their production units.

In the richer countries of the region, the losses sustained by the more vulnerable production systems are offset by government benefits or some kind of insurance mechanism. Usually, however, the more vulnerable systems – those that are not associated with the large agricultural corporations in some countries – do not have the necessary financial resources to protect them from risks relating to epidemics or the effects of climate change.

The large transnational corporations and those that conduct their own R&D have a high level of efficiency and efficacy (they produce what their consumer markets want, at the best cost-benefit ratio), while family production systems are being pushed towards subsistence farming.

Results of interaction between the systems

Income inequalities have increased because investment in agribusiness are controlled by the large transnational corporations, and investment in education, science and technology, and rural development has declined. Only a small group of producers (those in a more favorable position as regards ecological and economic conditions) are associated with these companies; thus, most production units are left out of their development plans.

There has been a general deterioration of the countries’ capacity to guarantee the sustainability of their agricultural production systems, especially the most vulnerable ones. This is reflected

dramatically in the decline in access to employment, housing, health and education, as well as in food security. Many rural workers are moving to the cities, where production activities (in general) have also decreased. The government, for its part, is not able to provide social safety nets for the large and growing poor population in urban settlements. The atmosphere is conducive to disturbances, protests and vandalism in many cities. Both the urban and the rural areas are increasingly unsafe. On the borders with rich countries (such as the United States), as well as those of some Latin American countries with higher living standards, there has been an increase in the number of deaths of people trying to cross the border in search of “better opportunities”. As far as urban food security is concerned, the food supply is inadequate, and the risk of contamination is high.

The situation with respect to climate change is becoming critical; temperatures are rising, and so is the frequency of extreme weather events. This is due to the fact that rich countries refuse to change their patterns of energy consumption, and they import massive amounts of raw materials from poor countries. This has led to increased exploitation of the natural resources of poor countries and loss of the protection afforded by natural forests. Environmental sustainability is not a concern, except for those countries that are most exposed and for the poor countries. Governments are not planning to take corrective measures.

2016-2030

Context of AKST systems and agricultural production

The countries within and outside the region are still applying all kinds of barriers, they find it difficult to achieve competitiveness, and threats of bioterrorism continue. The rich LAC countries that have a greater presence on agricultural markets are requiring obligatory certification, exercising strict control over production processes and imposing technology patterns for managing epidemics and ensuring food quality and safety.

Markets are becoming more and more divided: the rich countries (outside LAC) have control over the competitive process and the world markets. Very few LAC countries are able to supply commodities for external markets; the less developed and poorer countries have little access to these markets, and most of them are turning back to their domestic markets. These markets are comprised of a high percentage of low-income consumers who are concerned more about price than quality.

Epidemics are managed primarily with the use of specialized external inputs and services, which are very costly. There has been a decline in the capability of most LAC countries to take preventive and containment measures, as well as measures to adapt to and mitigate the effects of climate change. Consequently, epidemics are on the rise in the region.

LAC is experiencing even greater increases in temperature, compared with the previous period. The severity and frequency of extreme weather events has also increased. These changes have

had a significant impact, yet the countries have only limited capacity to adapt to and mitigate the situation.

The situation with respect to governance varies from country to country. In many countries, overall survival has been made more difficult by the actions of corrupt politicians who are associated with groups that are involved in illegal activities (which are often started as a reaction to the very limited opportunities available to many people in the cities). Only in a few countries do governments try to follow consistent and stable policies; however, their efforts are hindered by the scarcity of economic resources and by the constant turmoil arising from social disaggregation, epidemics and natural disasters, which are dealt with reactively.

With ever-shrinking resources, most of the countries in the region find it increasingly difficult to safeguard social order and production capacity and provide essential services such as health, unemployment insurance, education and housing credit. Legislation on environmental protection, security of commercial transactions, protection of knowledge and biosecurity, among others, are nothing but dead words. The richer countries, feeling threatened by this state of affairs, are setting up funds to alleviate the situation of those countries that face the most critical situations; thus, they are sending professionals, products (including medicine) and equipment to help these countries. This aid, begun around the year 2022, will be terminated by the end of the period.

As a result of the decline in resources and the deterioration of governance, the LAC countries are less able less able to manage regulations and quality standards than they were during the previous period. In some cases, only meager results are obtained. The assistance provided by rich countries to enhance capacities in those areas is inadequate and limited over time.

The education provided by the public system for the players in production systems is generally inadequate. The best education is provided by some of the private schools, but they are expensive and thus accessible only to a small percentage of the population. Some expensive private schools do not provide good quality.

Rich countries are making great strides in science. In biotechnology there has been a significant increase in understanding of the systemic effects of genetic manipulation. This allows for greater efficiency in the use of such techniques; in the rich countries, this helps reduce the negative environmental impact. Biotechnology has become the basis for breeding processes, while conventional processes have been abandoned. Nanotechnology, for its part, has produced the first successful results in the use of intelligent systems for monitoring plantations and herds. It has also been applied in the processing of food through the use of nano-electronic sensors based on DNA characterization, especially in detecting threats to biosecurity in raw materials or processed foods.

Nanotechnology is also used to develop systems for tracing origin and preserving identity. These systems are sold to poor countries that want to export their raw materials to rich countries and

have to meet identity-safeguard requirements. This technology is also used to generate strict protocols for monitoring biosecurity in international transactions.

Biotechnology is also used to develop plant-based biomass suited to the needs of agroindustry, of producers and of consumers in the LAC countries that are in a better economic position.

Development of alternative sources of energy is also beginning, as part of the effort to find sources that are cheaper than biofuels and which threaten to take over the market.

These advances are most often made by large transnational corporations that export their knowledge to the less developed countries. Agriculture can no longer be characterized as a site-specific activity.

AKST systems

Governments in LAC have practically abandoned research and science, which are now on their own. In many countries, markets are formed on the basis of traditional knowledge, given the scarcity of resources available to the population (for example, expensive medicines developed by international laboratories are replaced by active ingredients obtained directly from the local plant biodiversity). Moreover, there is no interaction between formal and traditional knowledge, and systematization and development of such knowledge is on the decline.

The generation of knowledge and technology is left up to rich countries outside the LAC region. The capacity to incorporate advances in formal knowledge is in the hands of large transnational corporations. In fact, no public institutes or universities have the capacity to perform that task effectively.

At the beginning of the period some effort is made, although not persistently, to incorporate traditional knowledge in the generation of agricultural products.

Resources for R&D are provided by the large corporations, which focus on their own short-term interests and on the needs of foreign markets. There is virtually no other source of funds for R&D, which continues to require a substantial investment of resources. The large corporations are mainly concerned with the competitiveness of commodities and on biosecurity protocols that will enable them to export to wealthier countries outside the region, using technologies that have been generated elsewhere and imported directly or adapted to the circumstances of LAC.

R&D in the large corporations is aimed almost entirely at improving successful products (such as genetically modified varieties) or testing new products to be sold on foreign and domestic markets. These organizations are not interested in species that are important in terms of their social significance (e.g., beans and yuca).

As far as R&D is concerned, the countries of the region have a comparative advantage – from the standpoint of the corporations – in that the environment can be explored without having to deal with the protests of large environmental groups. Taxes are low, and overall, there are not many restrictions.

The technologies generated by the corporations are not the most appropriate for the countries, bearing in mind their needs in terms of sustainable development, their culture or the conditions prevailing in their production systems.

Agricultural production systems

The slow economic growth of the region makes it much more difficult to incorporate knowledge into agriculture, particularly for the more vulnerable production systems. Moreover, the large corporations are no longer operating as organizations engaging in a broad range of activities (e.g., production of inputs), but rather as large and well-coordinated production chains combining the production and sale of those same inputs (including the relevant technologies) and the production and sale of agricultural products. In these chains knowledge is incorporated automatically as part of the process.

Production systems that do not take part in these chains do not have an adequate supply of technology to solve the problems created by epidemics or rising temperatures nor do they have the resources to adopt innovations when only a few such innovations are available.

The great majority of LAC countries have largely lost their ability to compete on external markets, for the following reasons:

(a) The rich countries are becoming more and more closed, as they want to keep the best markets for themselves;

(b) Rapid changes are taking place in the base of technology for economic development, which increasingly depends on expensive technologies such as nanotechnology, biotechnology, informatics, geomatics and the integration of these sciences.

(c) New products are being created with these technologies, which do not involve the use of commodities (the main export product of LAC), causing international prices for such inputs to drop sharply.

(d) The region has not been able to eradicate contamination and epidemics from agricultural activities.

In a few LAC countries, especially the larger ones, agricultural production is geared towards external markets. In all the LAC countries, the domestic market is a significant target for agriculture. In most of the countries, the domestic market is practically the only outlet; however, only the large corporations participate in chains. Small and vulnerable farmers supply the poor on the local market (or produce for self-consumption), and they find it increasingly difficult to be inserted into production chains (owing to their poor capacity to meet certification and biosecurity requirements).

Given the persistent poverty and the precariousness, in terms of production and social circumstances, which the actors in vulnerable production systems are faced with, they are provided for through social safety nets that are designed to mitigate potential social and natural emergencies.

The financial resources that are available for agricultural production activities are directed at groups that hold economic and political power rather than to small-scale producers, who are usually (traditional) families and indigenous peoples, especially in the economically backward countries.

As a result of poor governance, the resources allocated for agriculture tend to decline during this period in all the countries of the region, particularly in the poorest countries.

Medium-scale production systems, which depend heavily on government support, are efficient but are not able to meet market demands. They often lose out to the multinational production chains which export their products to LAC. The performance of these systems deteriorates as a result of their constant efforts to reduce production costs.

Results of interaction between the systems

Given the absence of proactive measures to mitigate climate change, large areas have become increasingly vulnerable and thus represent a greater risk to investors. There is aggressive competition for access to natural resources. Investment in agriculture is controlled by the transnational corporations, which receive support from many of the governments. This creates a volatile market for land and water and causes natural resources to be concentrated in a few hands. All of this exacerbates income inequalities.

Public resources for education have declined, depriving a large share of the population of access to information and organization. This aggravates income inequalities and deepens social inequality. The income gap is widening in some countries and remains stable in others, where there is some possibility of improvement thanks to the delivery of resources, such as the granting of title deeds (*titularización*) to small farmers. This helps attenuate the heavy migration from rural areas to the cities and to other countries, which has been increasing since the previous period.

A growing number of citizens have difficulty gaining access to health, employment, education and food security. A new segment of the population, made up of people who are employed by the large corporations, has been created; the middle class are losing their status. Social disintegration, violence and insecurity have become an increasingly serious problem.

Although the bromatological quality of foods available to the urban poor has been maintained at the standards prevailing during the previous period, the quantity of food for the poor in the large cities has decreased, in particular, for the following reasons: (a) the population of urban poor has increased numerically, owing to the lack of opportunities and jobs; (b) internal migration from the rural areas to the cities has been significant. The richer countries (including those in LAC) have established drastic standards to contain the inflow of migrants.

There has been a serious deterioration of the resilience of ecosystems, especially in the poor countries. These countries have very few restrictions on the exploitation of natural resources, and they have no capacity to restore degraded areas or to mitigate and adapt to climate change; moreover, the governments do not assign priority to that issue.

3.4.3 Life As It Is

2015

Context of AKST systems and agricultural production systems

The developed countries use trade barriers as a means for maintaining the competitiveness of their agricultural products. The small gains, in terms of barrier reduction, that have been made by countries that are producers of agricultural commodities, have been neutralized as new barriers have been established to deal with social or environmental issues.

The LAC countries that are already well established in the commodities markets (including Argentina, Brazil, Chile, Colombia, Ecuador and Mexico) are trying to enter the more dynamic markets (United States, China and India) and the market for differentiated products. Since they have lost much of their capacity to invest in technological innovation for agricultural production systems, they are still not able to compete in the market for differentiated agricultural products. They continue exporting commodities, diversifying their portfolio of products by including bioenergy items such as alcohol and biodiesel among their exports.

Consumers in the richer countries within and outside the region have begun to demand better quality, greater safety, more functionality and environmentally friendly production methods for food and non-food products, but they are not yet prepared to pay for the cost associated with those demands. There are market niches for certain differentiated products (e.g., products from the Amazon forest, the Chaco region in Paraguay, the salt desert of Bolivia or the Patagonian region). Domestic markets in LAC are mainly comprised of low-income consumers who demand food at low prices and of high-income niche consumers whose demands are different.

In most of the region, epidemics have increased in frequency or severity, owing to the lack of incentives for good practices in management of production systems and the absence of a capable national government structure and regional cooperation for preventing and mitigating the impact of new epidemics.

Temperatures are rising at the rate of 0.22ºC to 0.24ºC per decade, and extreme phenomena are becoming more frequent. The impact on agriculture and systems has been significant, although it varies according to each country's capacity for adaptation and mitigations.

Countries that have a more fully developed research structure are aware of the threat of climate change and hence of the need to orient agricultural R&D in that direction. Financial and management limitations have held back the effort to find solutions that could be applied in order to adapt to and mitigate the problem.

Some LAC countries adopt technological innovation, social development, environmental protection and biosecurity measures, but political and budgetary limitations cause the results to fall short of expectations. Changes in government authorities and managers of public institutions limit the continuity needed to obtain results. Since they depend heavily on external resources and are under pressure from rich countries, the LAC countries are implementing more consistent

biosecurity and environmental protection policies based on products imported from the rich countries and fully subsidized by them.

There has been a gradual transition towards the establishment and enforcement of regulations and quality standards. The government (at the beginning of the period) and the transnationals (at the end) have been responsible for managing sanitary standards and counterterrorism measures. These transnationals are still only interested in production chains of higher economic density, and this creates problems in regard to the consumption of foods produced by family farms.

Public education, especially in the poorer countries, does not produce good results, although the governments assign high priority to it. Likewise, the career options and courses offered by private education are often also inadequate. There is strong social pressure to improve the educational structure in the region.

While the rich countries are investing heavily in basic science to develop new technologies (such as nanotechnology, biotechnology and information science), the investments being made by a few LAC countries are limited. Consequently, the region is retreating from the cutting-edge scientific development that could bring significant advances in production technology for agricultural systems and agriculture per se. They provide even less for product differentiation and competitiveness.

In LAC as a whole, the value of traditional knowledge is only recognized by NGOs that are concerned with environmental sustainability and social inclusion and by some large private corporations that want to use this knowledge to create new products (e.g., pharmaceuticals or plant-based insecticides) that are much in demand for agricultural production systems.

AKST systems

Given the scarcity of economic resources in LAC and the social problems affecting the people, R&D is oriented largely to ensuring the food supply and enhancing economic efficiency, giving priority to increasing productivity in agriculture. Environmental sustainability and product differentiation and quality are not a priority for either the public or the private sector; these issues are addressed by R&D organizations and private initiatives.

The different LAC countries have different degrees of capability for incorporating advances in formal knowledge into agriculture; some (such as Argentina, Brazil and Mexico) also apply their limited advances in biotechnology and nanotechnology to the more dynamic production chains of agribusiness. The poorer countries, with limited resources and R&D infrastructures, are limited to adapting or importing technology. The few countries that have the capacity to generate technologies do not often apply traditional knowledge in generating those technologies.

Public R&D organizations have difficulty setting their course, defining priorities and, in particular, coordinating their overall research efforts. They have also lost personnel and technical and managerial capabilities, sometimes because professional staff members have retired and sometimes because they have moved on to activities where they can earn more.

As a result of the limited public and private investment in research and of the priorities set by R&D organizations, by the end of the period, there is a large gap between the scientific and technological capacities of the LAC countries and those of the developed countries (such as Japan, Germany and the United States) as well as between different countries within the region. For some areas of application considered strategic, technology is beginning to be imported from the rich countries, in some countries of the region, which leads these countries to consider renovating or creating new public R&D structures.

In the region there is still a significant difference between the countries: Brazil, Mexico and Argentina, traditional exporters of agricultural commodities, invest more public and private resources in R&D than the other countries; investments in the region are still at lower percentages than in other regions of the world. In certain production chains for export products, and in countries where laws were enacted to protect innovation, there is a growth of private investment in research.

Owing to the scarcity of financial resources and competition with other areas such as health and security, most governments in the region are cutting back on public investment in science, technology and education. The available international financial resources are being allocated mainly for environmental sustainability, social inclusion and biological security.

In the few LAC countries without more institutionalized public AKST structures, technology transfer and adaptive research programs are in operation. In the countries with more institutionalized AKST public structures, there is competition for workspace between the public and private sectors, primarily in relation to generating technology for more dynamic production chains. This competition between public and private organizations is driven by the economic return on investment in AKST, as a result of knowledge protection laws.

In the commodity exporting countries of the region, technologies generated by public and private AKST systems are oriented more to intensive agriculture for export, large and medium-scale agricultural producers, agroindustry, and input suppliers. There are programs designed to create value-added in family farming and to develop differentiated products.

Because of the persistent pressure of world public opinion in all countries, and especially in ones with fragile, threatened ecosystems such as the Amazon, or in countries with environments hostile to human life, i.e. semi-arid or arid regions, as is the case with Brazil, Peru, Ecuador, and Mexico, research programs are developed to protect and conserve the environment and recover previously degraded areas. The technologies generated are therefore adapted to these conditions, and take into account more vulnerable social groups, such as peasants or subsistence farmers, or indigenous communities.

Agricultural production systems

Volatile economic growth affects production chains in the region in different ways. In large corporations and major well-coordinated production chains, where everything from production

and sale of inputs, including technology, to production and sale of agricultural products is integrated, knowledge is automatically incorporated as part of the same process. Competition on the international market is a determining factor for incorporation of innovation in these chains. More vulnerable production systems that do not participate in these chains try in various ways to obtain the technology needed to solve the problems of efficiency and quality critical to entry on the market. Public credits are sometimes available for incorporation of innovations. Throughout the region, commodity-producing systems are formed, and consist primarily of large capitalist companies that produce for the external market and for internal consumption.

A sizeable proportion of commercial producers is linked to large production chains, such as the ones that participate in the highly fragmented but efficiently coordinated poultry chain. Others manage to find market niches in their own or wealthier countries by producing high value-added products.

Through constant efforts to improve the results of the government's public policies, many of the problems related to inclusion of farmers displaced by production chains, without access to commodity and factor markets, are solved.

The increased openness of markets and frontiers and the wider availability of public funds improved investment in agriculture, the sector that contributes the most to the economies of the countries in the region.

Investment in agribusiness still varies on the basis of export commodity prices, but within a narrower range, because of better coordination between stocks, production management, and commodity prices. Agribusiness is consolidated as the primary source of revenue for most LAC countries.

The performance of production systems is focused on increasing efficiency, based on increases in productivity and cost reductions. Large corporations have integrated all the agricultural and agroindustrial production processes, including production of inputs and the wholesale trade, leaving only retail marketing to third parties. Highly competitive production chains, with more of a national and multinational orientation, are strengthened in areas such as biodiesel made from soybeans and African palm and ethanol from sugarcane, driven by the demand for biofuels. Beef and fruit production chains become part of the region's economic portfolio.

Efforts to develop productive systems for specialized, differentiated products to meet social demand for high quality products are stepped up. There is a pronounced increase in organic production systems, boosted by implementation of a certification structure. Product differentiation has begun to produce results, with a growing R&D structure and capacity in technologies for processing agricultural products.

Results of interaction among the systems

Although consolidation of the production of commodities for the foreign and domestic markets promotes income inequality by hampering participation of the small producers in the most

dynamic agribusiness sector, programs for social inclusion, research oriented to family farms, and agrarian reform work to increase the income of many segments of small farmers. Moreover, a small group of producers with better ecological and economic conditions, who associated with companies that are part of production chains or produce for market niches for differentiated products, with a high value-added, improved their income profiles.

Access by citizens to health, jobs, education, and food security improves considerably during this period.

When problems of food security occur in the region, they are caused by climate and environmental problems and disasters. However, the region in general is able to produce enough to supply its domestic markets, and even to generate an exportable surplus. This is especially true of the agricultural commodity exporting countries (Brazil, Argentina and Mexico). For countries still dependent on food imports, with a lower per capita income, such as Nicaragua, Haiti, Honduras, Ecuador, Jamaica, and Cuba (de Ferranti, Perry, Foster, Lederman y Valdés, 2005), prices for these products increase, triggering food security problems.

Organized social groups continue to apply strong pressure to protect the environment, but they now have the support of international resources to implement effective measures.

Private enterprise, and primarily export commodity producers, partially includes environmental preservation costs in its plans, sharing related costs with the government.

In the poorest countries of the region and in the case of small farms or production by peasants, an improvement in economic efficiency, outside funding, and technical and management assistance incorporates environmental sustainability as a concern for production systems.

There is a reduction in deforestation, better use of fertilizers and herbicides, and the use of arable land is stabilized with the expanded production of biofuels.

3.4.4 Adaptive Mosaic

2007

Context of AKST systems and agricultural production

Concern with climate change and environmental sustainability is reflected in changes in various policies and regulations in some LAC countries at the outset, in the early years of the second decade of the millennium, in countries with greater governance capacity.

Initially, changes in regulations affect trade among countries (including LAC countries), through a strange combination of trade barriers: nontariff barriers, to block agricultural imports with doubtful environmental and social sustainability; and, the introduction of subsidies for environmentally friendly farm products.

Barriers hinder trade between countries. Moreover, for foreign markets, the competitiveness of agribusinesses in LAC countries is weakened in some, especially European, markets, that require guarantees that the production process respects environmental sustainability. New, differentiated products are not in demand for the “new consumers.”

Farm production is reduced, because of climate effects in many countries. The move in LAC for greater environmental sustainability also gives preference to consideration of ecosystems and to strict rules governing their exploitation in every country. All of this further reduces the productive capacity of agriculture, which as a result is now geared primarily to the domestic and even local markets. In other words, foreign markets are no longer the target for farm products in many countries.

Climate change contributes to the substantial increase in epidemics, leading to severe losses in terms of human and animal lives and a sharp reduction in harvests. These losses are distributed heterogeneously over the LAC, and also affect countries that contribute less (e.g., through CO2 emissions) to temperature increases and the severity of extreme weather events.

This scenario begins to take shape following large increases in the temperature in various regions of the world and the unprecedented intensity of extreme climatic events observed towards the end of the first decade of the 21st century. Countries and their governments do not prove capable of dealing with the crises generated by these changes. The performance of the governments in the region ranges from mediocre to acceptable. The profound institutional innovation required is driven by the strong mobilization of different social groups. For this reason, governments are largely forced to share all of their decisions and activities with these groups. Following world trends, some LAC countries begin to shift to more sustainable systems, based on what they have learned regarding the relationship between socio-economic systems and environmental systems. Several of the largest countries of the region, such as Brazil, Mexico, Argentina, Peru, and Colombia, are highly affected, because some of their ecosystems and population groups have been subject to extreme conditions for a considerable time, a situation further aggravated by the climate changes. For the first three countries in particular, it is difficult to make the transition to systems operating under the new paradigm, since they have economies and agriculture of scale that are commodity export oriented. For poorer, smaller countries, where agriculture was already geared more to products for local markets or niches, as in the case of Costa Rica and ornamental plants or Bolivia and quinoa, this transition turns out to be easier. Agricultural development policies are designed to facilitate the change in the production paradigm through specific R&D activities and the transfer and dissemination of the necessary traditional and conventional technologies and knowledge.

Polices for the integral development of biofuels and other sources of renewable energy are established, within a framework of environmental sustainability. Similarly, laws are adopted to provide incentives for agro-ecological farm production systems, and limits are set on agricultural operations that use large extensions of land or engage in single-cropping. At the same time, in the middle of this period, policies for facilitated access to land are instituted for small landless producers, as a way of minimizing the effects of climate on this vulnerable social group.

Education is a key element for making the institutional changes required for this new society. Around 2010, most LAC countries invest on average 13% of their GDP in education.

At the start of this period, we see the emergence in many countries of groups of scientists who advocate a more systemic approach to agriculture. For example, they say that research on the biosafety of transgenics should take into account the possible systemic repercussions of genetic manipulation on cells and the environment. These groups call for the use of more environmentally friendly practices in agriculture.

Moreover, they pursue advances in sciences such as biology and nanotechnology, and large investments are made in R&D in areas related to the environment and the impact of agriculture. This research provides the technological basis for environmental certification of farm products.

To reduce the risk of further environmental disasters, various international organizations, including the World Bank, UN, UNESCO, and WTO, among others, develop activities to organize and empower traditional communities throughout the world.

The knowledge of these communities begins to be more highly valued. Various initiatives involving environmental protection and certification of environmentally safe products and the processes for obtaining or generating them are developed. In many Latin American countries, there are initiatives to systematize this knowledge and elucidate the underlying principles.

AKST Systems

The demand for R&D has to do with improving agricultural processes, such as the following ones: (a) biological control of pests and diseases; (b) control of nutrient additives and residues in soils of the production system where they are used; (c) elimination/reduction of agricultural and agro-industrial waste or residues; (d) identification and use of natural sources of soil nutrient additives; (e) supervision of safety and quality in food processing; and, (f) generation of productive processes with a low environmental impact. Processes to increase productivity become less relevant. Priority is given to the following matters linked to the environment and ecosystems: (a) in-situ and ex-situ prospecting and conservation of germplasm; (b) enhancement of the economic value of biodiversity and natural resources; (c) sustainable economic exploitation of biodiversity; (d) traditional knowledge of biodiversity; (e) management of fish resources; (f) conservation-oriented agriculture, zoning, and management; (g) management of water quality and use; and (h) management of forest resources.

The existence of barriers favors research related to certification of origin systems and systems for ecological labeling of foods. A greater proportion of AKST goes specifically to research related to adapting to, or reducing the impact of, climate change. In defining AKST priorities, there is a greater need to deal first and foremost with adaptation to and mitigation (or reduction of the causes) of climate change, and environmental sustainability.

Small producers, subsistence farmers, and indigenous communities are now added to the social groups that have traditionally been users of agricultural research, as high priority groups to benefit from R&D.

In LAC, all countries are interested in and share efforts to ensure that AKST responds to the demands described, but only a few countries are in a position--with the infrastructure, trained scientists, and financial resources—to achieve advances in this area. Incorporation of AKST is partly limited by these resources, but it also cannot be achieved until after the potential impact on socio-economic and environmental systems has been assessed. All of those involved in science make major efforts to include traditional knowledge in formal AKST systems, guaranteeing the rights of communities.

Resources for R&D in some LAC countries are adequate, but not optimal. These resources are allocated on a priority basis to major environmental protection objectives, sustainable agricultural practices, and consumer safety. Most of these resources are national (government or social funds), while a small percentage comes from regional sources.

Strict biosafety protocols are defined for research in biotechnology and nanotechnology. Research in these sciences is uninterrupted, but progresses more slowly.

Management of R&D is important to ensure that it is correctly directed to environmental protection objectives. Different social groups acquire full participation in the integral agricultural R&D process.

R&D is largely under the leadership of research institutions and public universities, which work in a highly participatory fashion with users and other organizations interested in R&D and its social repercussions. Private companies cooperate to some extent with these organizations, but their sphere of action is more restricted by laws limiting their concentration. They are oriented more towards solving productivity problems and reducing production costs in productive systems, also in combination with environmental concerns. Towards the end of 2015, the vast majority of AKST private companies is guided by the idea that there are important markets related to the environment that are worth exploring.

In a situation of increasingly scarce resources, R&D endeavors to make it possible to use them efficiently.. Effectiveness, however, is more important than efficiency, or in other words the emphasis is on R&D products and on adapting them to the need for a reduced environmental impact, and to a lesser degree on optimizing the use of financial resources for that purpose. At the start of the period, few technologies were available for the large gamut of R&D users. By the end of the period, the capacity and the understanding of the needs of these users increase, as does the stock of different technologies available and appropriate for various users.

By the end of the period, after several years of attempts, more appropriate agricultural technologies are obtained for different productive systems, their crops, and their social, economic, and ecological conditions.

Agricultural production systems

Policies emphasizing sustainable local development require a strong agro-ecological knowledge component and the parallel development of various theories on valuation of natural resources and environmental services, as an integral part of the methodology needed to assess the economic efficiency of new production systems. Extensive social mobilization is also required. This stimulates and promotes the relevant technological innovation processes.

Advisory networks made up of public or private NGOs are established, to ensure multifunctional, sustainable management of production systems, disseminate technologies, and facilitate access to resources by agricultural production systems, and especially the most vulnerable ones.

The local markets served are very limited in volume and global scope. In fact, the countries in the region have imposed reciprocal trade barriers. Agricultural production chains are encouraged to help more vulnerable production systems become incorporated into those chains. The chains also become more limited in their geographical scope, and this facilitates the insertion of small producers. The participants in these chains work to improve productive processes and products, always with the environment as their frame of reference.

Pursuit of environmental sustainability as a priority goal has strong repercussions on access to productive resources: (a) It restricts use of natural resources such as fresh water sources; (b) It necessarily promotes access to development credits, which in turn facilitates acquisition of land by farmers; (c) It requires a phenomenal effort in basic training in the cultural, scientific, and technological areas, in order to bring the transformation of production systems to a successful conclusion.

In general, production systems supply relatively small, nearby urban groups, because they do not have the capacity to guarantee a food supply in the quantities at with the regularity required by densely populated cities. The largest LAC metropolises, such as Mexico City, São Paulo, Rio de Janeiro, Buenos Aires, Caracas, Santiago, and Bogota, are abandoned by thousands of citizens without employment or food options. Many people loot hypermarkets or urban businesses, while others go to the countryside, in an effort to sustain themselves directly by cultivating crops resistant to natural disasters, and especially food crops, such as rice, beans, corn, and yucca. This is another source of agricultural losses.

Results of interaction among the systems

Following the severe effects of climate change, an equally drastic change occurs in agricultural production systems. Many of the large single-crop commodity systems are affected and cannot withstand these changes. However, smaller integrated systems manage to survive and become stronger in this scenario. Thus, the rural rich and poor—at least the ones who are landowners—change places in many cases. There is also a change in the proportion of rich to poor in this environment. The most vulnerable groups, including subsistence farmers, rural wage earners, or communities producing for their own consumption, especially in environments previously subject

to the stress of frequent floods, droughts, and the like, are more severely affected by climate change. Many people leave their homes and seek refuge in the cities, where there are not enough jobs and food for all of them.

In addition, the effects of the change and the failure of many large-scale enterprises also displace no specialized workers, who were previously engaged in growing sugarcane in Brazil, or oil palm in Ecuador and Colombia, for instance.

In terms of income inequality, the results are also heterogeneous. However, if agricultural production systems are considered from the standpoint of small-, medium-, and large-scale landowners, this factor is observed to change hands: many rich owners leave the business and become poor, while smaller landowners producing crops and using crop systems with a lower environmental impact become stronger and grow. Moreover, rural workers in many cases lose their jobs, and need support to fulfill their basic needs. This situation is mitigated by policies facilitating access to land, water, credit, and knowledge. However, the employment issue is not completely resolved, because economic fragmentation causes a sharp reduction in agricultural production and job creation.

Access to basic education, health, employment, housing, and food security are goals pursued in a heterogeneous manner by the countries in the region. In the areas of education, health, and housing, the countries pioneering social and political change begin to realize their first successes, a trend that continues to the end of the period.

As for access to adequate quantities and regular supplies of food, in the cities success is relative during this period. This becomes an important problem in this scenario, because the number of people without access to regular supplies of sufficient quantities of food to meet their basic needs increases. Access is even more difficult for the poor, because the reduced supply triggers an increase in prices.

During this period of time, agriculture undergoes a major shift in objectives. It changes from a strongly productivist oriented system to one of profound environmentalist convictions. The quantity of products used in agriculture, such as fertilizers and pesticides, is reduced, and preference is given to environmentally friendly practices, which do not always result in greater productivity or a higher yield in the short run, but do guarantee continued agricultural production in the exploited ecosystems. There are also more health and sanitation controls, including use of pollutant-free production technologies.

Thus, after a profound crisis lasting for a good part of the earlier years, by the end of this period, environmental sustainability is beginning to show signs of improving.

2016-2030

Context of AKST systems and farm production

International trade barriers, and primarily nontariff barriers, continue in place, but countries agree not to impose restrictions on the exchange of information. The methods and procedures

developed during the previous period for ecological labeling of foods are perfected and expanded.

Continuing the trend of the previous period, competition among countries is virtually nonexistent. Countries give preference to producing for their own domestic markets, without major surpluses. In a few cases, and especially in cases where a country afflicted by natural disasters or social crisis needs help, food is exported and imported. In a few cases, there is also specialization of farm production by countries, based on their tradition, culture, and agro-ecological capacity. Consumers both within and outside LAC increasingly value products with certificates of origin and environmental protection. There is also a growing demand by consumers for nutritional quality and food safety.

In some countries or zones, epidemics are almost permanently reduced to the level of fields through better socio-environmental management, use of appropriate technologies, restoration of biodiversity, and improvement of the soil. The results are: (a) an increase in the production and marketing of better quality, healthy products, and (b) a higher value-added in these products.

The status of climate change is still troubling throughout the period. Many countries promote agricultural R&D oriented to adaptation to climate change and implement production systems specifically developed to that end.

The capacity to adapt to and mitigate the effects of climate change is more robust. Optimum governance conditions are strengthened throughout most of the region up to the end of this period. Agricultural development policies are pursued. Laws are passed to limit the size of large corporations left over from the previous period and new companies to be established, by way of restrictions on acquisitions and mergers. The intent is to guarantee a better balance of power among the different social stakeholders. A considerable part of the profits earned is used for initiatives geared to designing and introducing a new company. Many countries adopt regulations in conjunction with the Regionalization of Local Trade Initiative, permitting cooperation among transnational companies if they include local products and if the value- added is shared among all the partners.

Strict regulations and standards pertaining to the composition and origin of food, as well as to its environmental safety, are established and followed domestically and for the purpose of erecting trade barriers.

Moreover, the share of biofuels in the energy grid of countries is limited, to prevent new agricultural areas from being added, out of environmental concerns. Alternatives such as nuclear energy and also solar energy, captured and enhanced by nanotubes, emerge halfway through the period, as clean, already mastered alternatives to meet the immense energy requirements of a growing world population. There are many debates on their use, in which the final criterion is substitution of agricultural expansion (involved in the biofuel option) and the need for renewable energy from known sources.

The processes and activities of the preceding period are continued in the area of education. Local systems have managed to obtain results, after having overcome problems related to financing and teacher training.

Many cooperative labor initiatives begin to be developed in LAC, including the establishment of regional R&D institutions, which result in achievement of a critical mass of researchers, thereby increasing the likelihood of important progress in the new technologies (biotechnology and nanotechnology), and in a notable reduction in operating costs. These initiatives are based on the finding that R&D is becoming increasingly more costly, but is critical to the development of the countries in the region.

There are many projects shared among countries, designed to obtain the scientific backing of that guarantee of the production and supply of healthy, quality food for their people. Biotechnology and nanotechnology are used to generate knowledge pertaining to the reaction and resilience of ecosystems, but there is a lack of understanding of the interaction between them. This is reflected in the scant attention paid to impacts resulting from that interaction, and as a consequence, many natural resources shared by different countries are contaminated.

By the end of the past decade, indigenous and local communities begin to derive substantial benefits from the appropriation of formal knowledge in a wide variety of areas, and are highly organized. As a result, they obtain monetary income from diverse products derived from agriculture or biodiversity on the basis of that knowledge.

Failure to take care of shared resources, such as oceans, transboundary rivers, the atmosphere, and wildlife, to name a few, leads to a growing appreciation of traditional knowledge, which is gradually becoming more systematized. Its principles are explained by scientists from the communities themselves, who use formal knowledge for this purpose. These circumstances so favorable to traditional knowledge are not homogeneous in the world or the LAC.

AKST Systems

The existence of barriers promotes R&D on certification systems and ecological labeling of food. It also strongly boosts research on the relationship between environmental services and climate change and the repercussions of climate change on agriculture and ecosystems, and vice versa. There is also a heightened interest in (a) conservation and management of pollinating insects; (b) prospecting and sustainable management of plants; (c) identification and study of current and potential exotic invasive species; (d) use of genetically modified organisms and their impact on agro-biodiversity; and, (e) the impact of agricultural nanotechnology on human health and the environment. A highly relevant area of R&D during this period is devoted to developing sustainable productive systems capable of large-scale food production.

R&D systems apply to all social groups, but focus primarily on the most vulnerable sectors.

Moreover, the free exchange of information and scientists among countries, and the growing appreciation for science ensure the technical capacity of AKST for a good number of LAC countries.

Biotechnology and nanotechnology are disciplines that are important components of projects dedicated to this purpose. Traditional knowledge is increasingly included. Society's confidence in science is enhanced, and the controls on R&D implemented during the previous period are relaxed during this one, so that advances in basic disciplines can be included and thus improve people's understanding of the environment and its friendly use.

Resources available for R&D continue to be sufficient, but not abundant. Some additional resources are derived from credit and product certification services provided by some R&D institutions. There are difficulties in obtaining outside resources for this purpose. Social participation in generating knowledge and technologies for production systems is expanded. Coordination of the different interests of the various stakeholders and the need for a focal point for similar programs and projects lead to considerable inefficiency in the use of financial resources, infrastructure, and capacities.

At the outset of this period, private R&D organizations, which are much smaller and less powerful, begin to participate more in R&D efforts, in cooperation with public organizations.

R&D achieves important progress in understanding ecosystems and their management. Environmental services are improved as a result of a better understanding of their impact on the environment. The efficiency and effectiveness of scientific activity have increased considerably since the previous period. Efficiency is needed to rationalize the use of scarce resources, and effectiveness or efficacy is important because the participation of many stakeholders—including users, among others—in defining and obtaining a technological solution makes it possible to build cross-disciplinary structures better adapted to needs. On the other hand, the time until the start of project implementation is prolonged, due to application of collective participation practices. There are cases where the results are delayed so much that they are no longer relevant for the users.

The participation of many stakeholders in developing knowledge and technology is also a factor that favors the attainment of appropriate technologies, but sometimes they do not reach the systems in question, either because of delays in obtaining them or because the information on them is not adequately disseminated.

Productive agricultural systems

Efforts to incorporate knowledge into agriculture are pursued actively by all stakeholders that could be affected. Decision-makers are also involved in these efforts, so that they can reduce the unfavorable impact of transition from the preceding period and promote increased agricultural production. However, policies to emphasize sustainable local development allow for more inputs of agro-ecological knowledge.

The markets served are essentially the domestic markets of each country. A few specialized markets are generated as a result of the gradual specialization of countries in certain farm products, where they have a comparative advantage in terms of the crops, tradition, agro-ecological conditions, and the like.

Most actors in vulnerable production systems are highly organized, a trend promoted by the decentralization of rural development planning and the greater importance of local initiatives. Development of community organizations includes social organizations fostered by production chains or cooperatives in communities.

There are resources for support of agriculture, mainly targeted to protect it from natural disasters. But these resources are not abundant, since there are many social demands to cover with little money. In the last decade of the period, both agricultural production systems and cities suffer from limited access to water, especially in the semi-arid zones of Latin America in Brazil, Mexico, Argentina, Peru, and Colombia. This reduced access displaces subsistence farmers and reduces farm production in many countries.

The products and processes of virtually all agricultural systems are more environmentally friendly and more healthy. As in the preceding period, there are still problems in obtaining food in the quantities and with the regularity needed to provide for the entire population.

Results of interaction among the systems

Farm income does not increase very much due to the dynamics of the local markets. Policies developed by countries to reduce the agrarian income gap during the previous period are improved and show results. Indirectly, the reduction of the income gap leads to a return to rural areas by many who migrated to urban centers, thereby partially alleviating the problem of food supplies for the urban poor.

With regard to education, health, and housing, these countries achieve greater success than in the preceding period, and this success continues to the end of the period. Access to jobs is somewhat better than in the foregoing period, because agricultural systems acquire greater capacity and experience, and thus are more efficient than before. Many of these systems also achieve economic sustainability by the end of the period.

Healthy food is guaranteed for the urban poor who have the capacity to purchase it in the cities. However, in terms of ensuring food in sufficient quantities and with the required periodicity, success is not complete in this period. The increase in the population and in the demand for food triggers major social conflicts during this period, brining many countries to include the guarantee of the right to food in their Constitutions. This partially solves the problem, since the short supplies are then democratically distributed amongst the poor.

The result in terms of environmental sustainability is, on the one hand, an improvement in protection of ecosystems in local areas. On the other hand, however, natural resources shared

by several countries frequently suffer from the effect of different and sometimes negligent management systems, which in turn have repercussions on the others.

3.4.5 Technogarden

2015

Context of AKST systems and agricultural production

The governments of various European countries begin to eliminate farm subsidies and tariff barriers, due to pressure applied on the WTO by poorer agricultural countries and other international organizations. This liberation results in heavy flows of imported foods and the resulting expansion of supermarkets in some LAC countries.

Throughout this period, nontariff biosafety barriers are implemented and strengthened based on environmental protection (certification of sustainable production processes in the country of origin of farm products, and of a low environmental impact as a result of their use).

Although agricultural diversification, initially in the rich countries, leads to greater environmental sustainability, it also diminishes the food production effort in them, which then shifts even more to the poorer countries. Whereas these poorer countries were already engaged in farming, but only production of commodities, they are now involved in producing differentiated products with a higher value-added, and they are also beginning to diversify their agriculture. This latter trend is observed primarily in the countries with greater biodiversity, such as those that share the Amazon biome in the region.

The free circulation of information and persons around the world increases the diversity of consumer demand for differentiated food, based either on flavor, appearance, nutritional value, nutraceutic properties, healthfulness, or other factors. In many countries, consumers require certification of the food processing procedures, to ensure that they do not involve agro-toxins, child labor, GMOs, animal suffering, and the like. Many consumers now are familiar with the food tradition of other cultures. Consequently, they are increasingly demanding the inputs needed to prepare this type of ethnic cuisines in specialized restaurants. Traceability requirements also increase. In LAC, the increasing level of education of the people and the growing availability of information on food also step up consumers' demands.

Agricultural epidemics increase in frequency and severity. In LAC, few countries have the technical and managerial capacity to reduce or eliminate them.

The situation of climate change is troubling throughout the period. Companies are aware of the possible effects of climate change on production systems. A decade of droughts and floods serves to aggravate these concerns over the effects of human activities on the climate and the environment, enhancing the value of environmental services in these countries. A visible consequence of this enhanced appreciation is that consumers in the wealthier countries begin monitoring agricultural production processes. These consumers organize to draw attention to patterns and procedures which have a low environmental impact and entail offsetting benefits,

such as preservation of forests. This leads to strict global regulations on products derived from agriculture and on their import.

Many LAC countries make large strides in institution-building throughout this period. Although governments with different platforms take office, in many countries their policies are more stable and coherent, and especially their development policies, which are now regarded as a multi-dimensional phenomenon comprising economic, social, and political factors.

In many Latin American countries, compensatory polices for the poor are put in place at the beginning of this period. In a few countries, these policies are not accompanied by employment programs, and so an improvement in the social and economic status of these groups is short-lived. In a majority of the countries however, they also manage to implement more consistent, successful, and lasting policies in the areas of employment, education, and health. Many countries have laws to protect investment in science, as an incentive.

As for the environment, many countries made advances in institution-building, leading to the managed exploration of natural resources. This institutionality entails application of rules and norms to ecosystems and segments of ecosystems for possible development (or not) . These norms also govern the type of development allowed, conditions for such development, etc. Participation in the global market leads to a rapid improvement in regulations and standards and their rigorous enforcement, to comply with food quality standards.

In some LAC countries, little progress has been made in educating the people. But even in those countries, minor improvements are seen, consistent with the trend recorded during the previous decade. In most countries, fortunately, notable advances are seen in education. Even the actors working in the most vulnerable farm production systems show a substantial improvement in their level of education by the end of this period.

At the outset of the period, there is still distrust regarding the true intentions and uses of science. However, certain successes towards the end of the period produce renewed enthusiasm for the benefits of scientific activity. There is also considerable progress made in the world and in LAC in laying the groundwork for scientific activity, especially in view of the major ethical dilemmas surrounding this activity in modern times.

R&D globally applied to agriculture begins to shed light on two aspects: one is a more profound understanding of the impact of human action on ecosystems, with a view to reducing that impact; and, another is a specific appreciation for environmental services, as a way of developing policies to promote diversified use of the land (agricultural production and environmental services). On the other hand, major efforts continue to advance knowledge in the fields of biology, nanotechnology, and information sciences, and their integration.

Rich countries, especially those belonging to the European Community and the United States, continue on their course of intensive scientific and technological development focusing on the facilitating technologies, such as biotechnology and nanotechnology, and information

technologies. A critical factor in competition among countries is the development of new products. Frequently, and even for the purpose of guaranteeing genetic variability, research institutions avail themselves of biodiversity resources, which are in the hands of less developed, and especially Latin American, countries.

Laws on biodiversity rights in most of these countries are relatively inefficient. Thus traditional knowledge is not highly valued and remains isolated from formal knowledge in the vast majority of cases. The increased value attached to environmental services gradually changes this picture.

AKST Systems

Concern over the environment and environmental sustainability in agriculture grows throughout the period, as a result of increases in the temperature and frequency of extreme climate events in the region. As a result, R&D priorities in the LAC include knowledge of the environment and its relationship with agriculture as a highly relevant issue. This priority is reflected in the heavy investment of resources in research on this topic. Various R&D programs are also initiated specifically for the purpose of adapting to the impact of climate change, and mitigating it or reducing its causes. Midway through the period, investment in research designed to measure and enhance the value of environmental services and biodiversity is stepped up.

AKST assigns priority to processes: (a) control over the addition of nutrients and residues to the soils of the production system where they are used; (b) treatment and recycling of agricultural and agro-industrial residues or waste; (c) the specific assessment of the need for inputs, water, etc., for development of plants (precision agriculture); (d) safety and quality guarantees in food processing; and, (f) generation of varieties and strains adapted to hostile environmental conditions. Processes designed to increase productivity are not as important. Priority is given to the following issues related to the environment and ecosystems: (a) economic evaluation of biodiversity and natural resources; (b) sustainable economic exploitation of biodiversity; (c) management of fishery resources; (d) management of the quality and use of water; and (e) management of forest resources. In terms of the social groups to which R&D is oriented, by the end of this period an important shift occurs, from traditional large and medium-scale producers to end users or consumers, agroindustry, and policy-makers, in the first place, and finally to merchants and subsistence farmers (Castro et al., 2005; Lima et al., 2005). Indigenous communities and small producers are not relevant to R&D institutions during the early part of the period, but this situation changes over time, due to the growing interaction between researchers and these communities.

The greater awareness of the importance of science and R&D also means that LAC scientists are valued more highly. They work in close cooperation, forming multi-institutional research networks with scientists from many LAC countries and countries outside the region. This facilitates advances in knowledge within LAC and also incorporates knowledge generated in countries in other parts of the world.

Throughout almost the entire period, traditional knowledge is not given serious consideration as a source of technologies by formal LAC systems. In 2013, with the impact of climate change on LAC, many countries begin to debate the advisability of using traditional knowledge to define practices for adaptation to extreme climate phenomena. Little by little, traditional communities are also being viewed as sources of knowledge on the different biomes and the environmental services they provide. This effort is limited to just a few countries. As a result of more sustained economic growth, during this period most of the LAC countries have financial resources for long-term investments, such as R&D. They also already have a critical mass of scientists internationally reputed in their fields. The processes of management and implementation of R&D projects are more and more professional, based on detailed studies of the future and long-term planning. They also increasingly involve other stakeholders interested in the outcome of R&D activity.

Research and development is an arena in which public and private R&D institutions compete and cooperate. The two sectors have the financial resources and the skills needed to use them effectively. A division of labor is established, according to which certain more profitable commodities, such as corn, tobacco, melons, papayas, forest species, and cotton, and most products with a higher value-added are produced by the private sector, whereas commodities such as rice, beans, coffee, citrus fruits, wine grapes, yucca, mangos, bananas, and cashews are of strategic importance to the public sector. The two sectors cooperate in some areas of research, such as in soybeans (Castro el al., 2006).

Research in LAC produces important results for agriculture. In food chains, there is progress in certification, traceability, and food safety in general. There are also important developments in the area of biofuels. Brazil's successful experience with alcohol as a substitute for gasoline is used as an example for other agriculture-based energy sources, including palm oil, which is used as a substitute for diesel in Brazil itself, as well as in other LAC countries. As a result of heavy investments in the environment, around 2015 progress is made in beginning to solve the thorny issues of the economic value of biodiversity and natural resources in rendering environmental services and in sustainable agriculture. Considerable efforts are also devoted to management of forest resources and the quality and use of water, which became a source of concern after the effects of climate change observed during the period. The technologies generated by public and private R&D and by extensive social participation in the research process are generally appropriate for the systems they are meant for and are also close to an ideal of what could be regarded as the most appropriate technologies for sustainable development. This is true even for more vulnerable social groups, who were not given priority at the start of the period.

Agricultural production systems

The situation created by random climate changes spurs on intensive action to incorporate relevant knowledge in agricultural production systems. The actors in smaller production systems

are organized into groups linked to them, involving compliance with rules of efficiency, standards, and certification.

The intensity and types of action to incorporate knowledge vary widely in the region.

In this scenario, incorporation of knowledge in agriculture is a business affair. The producing companies train their workers in the use of innovative techniques and inputs to improve the productivity and sustainability of the systems, resulting in incorporation of knowledge.

Companies also require implementation and verification of a series of practices to fulfill market requirements. Similarly, actors in smaller production systems are organized into associations, to ensure compliance with rules of efficiency, standards, and certification.

Genetically modified organisms are used more frequently and for a growing number of producers in all the LAC countries. The costs of using these technologies decline, and their use is expanded throughout the region. At the beginning of the period, use of transgenic organisms, which lead to an increased use of environmentally harmful inputs, such as herbicides, create conflicts with producers within and outside the region that defend environmental protection.

Some cases of contamination in units producing biopharmaceuticals lead to a major social rejection of this type of technology towards the middle of the period. But the introduction of new agricultural varieties adapted to hostile environments and of transgenic organisms capable of bioremediation, in cases of soil contamination by pollutants, for instance, and of preventing soil erosion result in the more widespread use of these organisms and their acceptance by LAC companies and their markets.

Large production systems, which are highly technified, send their products to external and internal markets. They are an integral part of the major production chains, with a high degree of coordination and an in-depth knowledge of the markets served and consumer demands. Most small farmers, and also some groups that are engaged in subsistence farming in the early part of the period, succeed in becoming part of some of these chains, or they participate in certain market niches, by producing goods for a more limited public, such as the demand for frog meat.

There is a sharp reduction in the number of subsistence farmers.

From the very beginning of this scenario, abundant resources are allocated to foster and disseminate the incorporation of knowledge into agricultural production systems. Because of the economic efficiency and product quality of production systems, they receive considerable inputs, especially in terms of credits and knowledge, in preference to land. The goal is to increase the productivity of agricultural production systems. Moreover, some of these systems are also involved in offering certain environmental services, which are encouraged by the end of the period in many LAC countries.

Due to the influence of climate change, some regions begin to experience problems in acquiring an adequate and a regular water supply for the operation of their production systems.

The major production systems that use modern production and management methods are successful in operating with great efficiency and with high quality processes and products, and also manage to enhance their competitiveness. There is a large component of knowledge and technology in these products and processes, although the external market still prefers commodities to differentiated products, which are left for the extensive internal LAC market. This situation does not change until the end of the period, when some large developed markets begin importing a larger proportion of differentiated LAC products.

The production systems of small farmers are inserted into the large chains coordinated by private national or transnational corporations as suppliers of inputs, or else as producers of raw materials in other chains (in other words, as an independent component of these chains, not coordinated by another component, such as in the first situation described). These small systems focus on commodities or on a few differentiated products.

The vast majority of production systems which are independent but are part of production chains also generally achieve success, but this is not the case in situations in which unforeseen factors, such as increased temperatures, natural disasters, or epidemics, threaten the effectiveness of these systems.

Results of interaction among the systems

The improved performance of productive activities, especially from the standpoint of economic efficiency, begins to have a positive effect on income inequality. The need for a substantial improvement in the quality of products and services, as well as the need to focus on the environmental impact of these products and services, generally improves market prices.

During this period, there is generally a substantial increase in the indicators of greater social equality: improvement in access to education, employment, health, and food security. In a few Latin American countries, these advances are more limited. Positive changes are seen in the indicators of urban food security and safety due to the following: the processes for understanding and monitoring the handling, packaging, and processing of foods are improved; and, environmental adaptability traits are incorporated into many varieties and strains, leading to a general increase in supply, and thus a reduction in the prices of these foods for urban consumers.

In the beginning of the period, agriculture in rich and poor countries is mostly based on exploitation of ecosystems, with raw materials or processed foods generated as a result of this exploitation. In other words, commodities or differentiated products are generated, but they are always derived from human action on nature. Little by little, beginning with the European countries and then in the United States, global agriculture becomes diversified and begins to include environmental services as part of its functions. These services range from protection of water sources, carbon separation, protection of habitats for pollinators, such as birds and bees, and reduction of pollution generated by agriculture, to simple preservation of plant and animal species.

As a result, environmental sustainability indicators in agriculture are improved.

2016-2030

Context of the AKST systems and agricultural production

Free global markets are consolidated.

Biosafety and environmental protection barriers are further strengthened.

Competition for markets focuses on product differentiation achieved by using environmentally friendly technologies. The LAC increases its share in these markets. Throughout the world, the price consumers are willing to pay for products linked in some way to environmental protection initiatives increases. Thus certification that the products were developed in organizations that provide an environmental service of some sort is a factor of added-value. For this reason alone, commodities become differentiated products.

The LAC still operates in commodity markets, especially food commodity markets, where rich countries are the major importers, since agriculture has disappeared in some of these countries. In these countries, the raw materials produced by less developed countries are still used, when necessary, to make new products by chemical and/or molecular manipulation.

Consumers throughout the world, including in LAC, are ready to prevent any threats to the environment, because some notable natural disasters that occurred towards the middle of the period destroyed several Japanese cities. Therefore, consumers value any products made with a view to protecting the environment and ecosystems, either in terms of the production procedures used or because the production systems involved also offer environmental services. But consumers also demand new and original types of food, at the same time that they pay close attention to issues related to health and to contamination, as a result of molecular genetic modification.

Epidemics are better controlled, with longer stretches of time between them. But they increase in intensity, because new agents of disease are particularly robust and difficult to control.

The climate change situation is a source of concern nearly to the very end of the period, when the rate of increase in temperatures begins to decline. This reversal is attributed to the large-scale development of sustainable technologies used intensively by the productive sectors of countries.

In most countries, governance is close to optimal, with stable objectives and consistent policies, which do not reflect the different leanings of the governments in office.

Concern over environmental services and the environment and its protection induces many countries to pass laws to guarantee an economic return to enterprises that are proven to operate in such a way that the country and the world are assured of receiving a specific environmental service. In addition to environmental protection, these laws ensure that many people who would have found themselves jobless and displaced to the cities can find work that provides for their sustenance.

As LAC governments observe this unplanned consequence of their environmental protection policies, they implement laws to allocate land for the sole purpose of preserving the environment and ecosystems. These lands, owned by the government, are run by managers selected amongst the poorest citizens, on the basis of the proposals made by these persons to ensure the sustainable management of these properties.

In LAC there are policies to promote tourism that promise a return to nature, with farms or country properties that operate in the same way as in the mid-twentieth century, and are like large entertainment parks where tourists interact with persons and not machines. Activities having to do with appreciation of the art or cultivation of body esthetics are also highly encouraged, as an ideal way to avoid deteriorating health or to reduce mortality rates.

Investments in R&D produce an economic return guaranteed by sustainable polices to protect knowledge and by good management of these policies. In the field of education, this is increasingly more highly valued and guaranteed, as is the health of citizens. Education is provided partly by the State and partly by corporations, that employ highly qualified persons. These persons, however, must be more and more highly specialized in order to meet the performance standards required by increasingly knowledge-intensive systems.

Large properties are highly assessed, so that governments can establish and maintain unemployment insurance for the unemployed in a highly technified world. There are also incentives for corporations not to lay off employees when they adopt new or modified technologies.

Unemployment increases because of the intensive pace at which technology is incorporated in all activities. This increase, however, is offset to some extent by policies to encourage new economic activities.

Action to improve regulations and standards and their enforcement is completed.

R&D provides a basis for evaluating environmental services on the basis of research that combines biotechnology and nanotechnology. Public institutions in some LAC countries assist in this research.

There is enormous progress in almost all areas of application of biology—animal and plant production, processing of quality, healthy foods, biomanufacturers of industrial raw materials, the environment, the biomass and new nonfood products—and also nanotechnology—animal and plant monitoring and therapy, monitoring of food processing, detection of pathogens, viruses, and GMOs in raw and processed materials, identity preservation systems, and monitoring and environmental treatment systems.

Biotechnology and nanotechnology, as well as soil physics, are integrated and produce spectacular results for environmental remediation.

In agriculture, we see the development of varieties adapted to hostile environmental conditions--such as drought and salinity for plants, and bovine species adapted to ingestion of sea water--

through genetic manipulation. These are a few examples of advances produced in LAC countries.

Growing worry over the maintenance of environmental services in all countries leads to a gradually increasing appreciation of traditional and local knowledge. Thus many practices of indigenous and traditional communities are recovered for use, because the continuity of these services is more easily guaranteed. Many communities obtain economic returns from this knowledge, because consolidated laws guarantee it. Preservation of biodiversity is in and of itself regarded as an environmental service (such as preservation of watersheds and reduction of pollution), because the important role played by the coexistence of different species of plants and animals in the preservation of many ecosystems is an accepted fact. In various LAC countries, traditional knowledge, in interaction with formal science, is also highly relevant to the growing understanding of biodiversity and its uses. The tremendous advances of science once again bring out fears throughout the world regarding the ethical limits of scientific activity and technological innovation. Innovation applied to products and processes generates a debate among various social groups revolving around the expected use or purpose of nature, as known and appreciated. Advances in science and its applications also generate more pragmatic problems, because the brand new technology is almost completely autonomous and no longer requires the use of as much labor as before, especially unskilled labor (although average qualifications are high during this period, equivalent to a secondary education). Consequently, there is pressure to reduce the pace of scientific development, and the LAC is no exception.

AKST systems

Priorities for R&D in LAC include the following: application of recent advances in the valuation of environmental services fin order to establish protocols that make environmental protection an adjunct to agriculture; application of advanced biology and nanotechnology to production of food and new materials, that can be used in many productive areas, including health, pharmaceutics, agriculture, industry, and the like; use of micro-organisms for environmental remediation; improvement of nano-systems for monitoring diseases and applying therapy to animal or plant groups; and, systems for identity preservation, for tracking or tracing and monitoring, and environmental recovery. Priority is also given to developing alternative technologies that provide for the continuity of agriculture in conditions of climate change, and make it possible to prevent increases in these phenomena by reducing the factors that are contributing to them.

In LAC, the AKST focuses on all social groups.

The capacity of professionals in science and technology in LAC increases daily, because, through publications, attending congresses, or joint projects, they participate jointly in the worldwide development of science and technology. There are virtually no prolonged lapses of time between an advance in one area of knowledge and its application to productive activities.

There is a vigorous move to systematize traditional knowledge, which is massively explored by formal science, under national, regional, and international agreements or laws guaranteeing the rights of the peoples and the harmonious interaction between the two types of knowledge.

All productive and economic activity depends on the continuous progress of R&D. Governments and corporations therefore give priority to investment in knowledge and technology. There are plentiful resources for this purpose. Management of R&D is regarded as a strategic factor of competitiveness for companies that develop agricultural technology. This is true because the time between the design of a new product and its entry on the market is increasingly shorter.

There is also growing social participation in the research process, since private R&D organizations feel more and more pressured by a public that has concerns regarding their power. This participation is concentrated in management processes, and it is limited—by the specialized knowledge required—in cases of technological development projects.

Public and private organizations still work in cooperation, but the role of private enterprise in R&D is on the rise. In terms of products and services developed, this means that there are now few species of plants or animals that the private sector is not interested in, and that are therefore left to public research. There is also stepped up private interest in basic science, because of its capacity to generate knowledge that serves as a basis for future practical applications. There is an impressive array of plant and animal species with sequenced genomes. Functional and structural genetics has also made great strides in understanding gene functions. This progress was achieved to a great extent by cooperation between public and private science.

Research becomes increasingly more effective. In other words, in short periods of time, it is capable of generating completely new products and services required for equally new problems in production systems, ecosystems, and their interfaces. But because of the abundance of resources, people are no longer as concerned about the efficiency of R&D. R&D becomes more and more expensive, even in situations allowing for a more rational use of resources to obtain a specific result.

As for products and services obtained from R&D, they are now almost entirely problem-specific or demand-specific, because they are designed to solve a specific problem or specific demand of a social group. This highly expanded portfolio of products and services is also one of the reasons for the relative inefficiency of R&D in these circumstances.

There is a substantial improvement in understanding social, economic, biological, and ecological systems. Technologies are increasingly better adapted to the systems to which they are to be applied. This adaptation is still not perfect, though. New problems arise periodically in these systems, as a result of the unanticipated interaction between the new technologies and their effects, and the emerging properties of the systems.

Agricultural production systems

Throughout the period, new knowledge has been incorporated into production systems at an intensive rate. Different action taken in other human endeavors leads to an appreciable mitigation of climate change. Relevant technological changes introduced into production systems contribute to this mitigation. There is also considerable progress made in adapting to the effects of climate change.

In this scenario, the incorporation of knowledge into agriculture is handled by companies that train their workers in the use of new techniques and inputs to improve the productivity and sustainability of the systems. Companies also require implementation and verification of a series of practices to meet market requirements. Company workers or partners have to incorporate a pool of complex knowledge associated with standards for products and production processes.

The major production systems, highly technified, send their products to external and internal markets. These systems are part of large production chains, with a high degree of coordination and a profound knowledge of the markets served, and of the demands of consumers using those markets. Processors of basic farm products participate as suppliers of pretreated raw materials (i.e., products that have been subjected to some form of processing after primary production) to these major production chains. Virtually all systems include new nonagricultural activities—environmental services, tourism, rest homes—that are integrated into the farm-based activities and serve both domestic and foreign markets.

Major production systems and independent producers are well organized in defense of their interests, with a high degree of professionalism.

Most independent producers manage to insert themselves into chains and markets, but small producers are still displaced to urban areas.

The policies of plentiful available resources for incorporation of knowledge into production systems are maintained. The region tends to become standardized in its technological endeavors, which leads to a relatively abundant level of resources throughout the region.

Problems of access to water are solved by new technologies for reusing waste waters and by desalinization of salt water. Land as a resource, aside from environmental protection, is guaranteed by successfully using degraded environments that were previously considered hostile to life.

Major production systems using modern production and management methods are able to operate with great efficiency and high quality processes and products, and this greatly increases their capacity to compete in markets. A high degree of knowledge and technology is incorporated into these products and processes, thereby generating countless differentiated products.

Production systems on a smaller scale (there are no more “small producers”) participate as suppliers of preprocessed raw materials (i.e., that have received some type of processing

following primary production) for these large production chains. The vast majority of the production systems are successful overall.

Results of interaction among the systems

If consideration is given only to agriculture-based productive activities, income inequality can be said to diminish considerably during this period, as a result of the insertion into the powerful, transnational production chains of many who were small producers in the previous period. Thus all the social groups that participate in this activity benefit from increased incomes. However, wage-earners who were working in the fields before production was completely technified lose their jobs and migrate to the cities, which are now faced with an increased demand for basic services and food. Access to education, health, housing, and food security is guaranteed by governments in various ways. Employment, however, is not guaranteed, although agricultural diversification has helped increase it, and governments have implemented mechanisms to create alternative job markets and compensation for the unemployed.

Urban food security and safety are guaranteed with the abundant supply of cheap, diversified foods meeting high sanitary standards.

The sustainability of farm production systems gradually increases throughout the period, as a result of the use of more sustainable technologies, and also because agriculture has another paradigm, since traditional production systems are almost always accompanied by environmental services. Another important reason for increased (but not complete) sustainability is the use of regulatory procedures and standards in the technified countries of the region. There are also isolated cases of newly emerging environmental problems, as a result of technological solutions that create many new environmental problems.

3.5 Implications of these scenarios for innovation and development policies

In looking at the areas of convergence and divergence in the scenarios described in the earlier section, we can deduce implications for innovation and development policies in the fields of education, food security, employment, income, social development, and social protection, and determine which ones would most likely increase the probability of achieving better indicators of sustainable development. These policies have to do with technological innovation first and foremost, because the initial goal of this evaluation is to try to identify its contribution to sustainable development in the future. But since technological innovation alone would not be enough to determine the desired changes, for vulnerable groups it is also necessary to think in terms of other policies and strategies that are not technology-oriented, to achieve the same end.

3.5.1 Implications for technology innovation policies

In the case of technological innovation, first there must be mechanisms to promote development of technologies (especially processes), to focus on health, environmental, and biosafety barriers appropriate for the most vulnerable social groups. These mechanisms should be based on

research into both the socio-economic and the cultural conditions of these groups that could either facilitate or restrict the adoption of certain technologies. They should also involve programs to transfer these technologies for use by these groups.

More precise protocols must also be developed to identify the potential for epidemics and to reduce food contamination, particularly as a result of improper handling, and low-cost technologies for identification of pathogens and for decontamination.

Innovation for vulnerable groups should also focus on processes for adaptation and mitigation of climate change that are suitable for these social groups and their economic, social, cultural, and production conditions.

With regard to the actual generation of technology, innovative ways of doing this must be developed, such as international cooperatives, especially involving the more highly structured LAC countries and the ones with less capacity. At the same time, the ongoing training of new research workers must be guaranteed in the areas most relevant for understanding and care of more vulnerable groups and their needs, and the infrastructure needed to enable the AKST systems to continue to be competitive most be provided.

There is also a clear need to determine specific funds to meet the needs of the most vulnerable social groups (generation of technological solutions). A mechanism of this sort will encourage understanding and help generate solutions to the problems faced by these groups in their agricultural activities. It will also prevent resources from being diverted to other demands for new technology.

3.5.1 Implications for (non-technology) policies to support vulnerable social groups

As far as non-technology policies are concerned, the focus should be on promoting the following:

a) attention on the part of vulnerable social groups to the requirements established in environmental, health, and biosafety regulations;

b) insertion of vulnerable social groups into organized production chains; these mechanisms should consider common needs identified between those groups and the chains;

c) education and training of groups of vulnerable farm producers in terms of best practices and use of low-cost technologies, and in mitigation of the effects of climate change, and management of natural resources;

d) support for vulnerable groups facing the loss of their production or productive capacity;

e) organization of groups of vulnerable producers to increase their scale of production and capacity to market their products;

f) farm production geared to profitable market niches, in which vulnerable groups would be likely to achieve success.

It is also important to develop mechanisms to guarantee access to natural resources for the most vulnerable social groups.

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