Symposium CONCEPT NOTE (2nd version)

The Bioeconomy in Latin America and the Caribbean: Towards a socio-economic research agenda

Executive Summary

A society less dependent on fossil fuels is very different from the one we know today, more decentralized, with smaller scale requirements, with different intersectoral – rural/urban, industrial/agricultural, etc. – and international trade relations as a consequence of the changing balance in strategic resources. All this is leading to a new economic landscape (comparative advantages, country, sectors, products’ competitiveness), and is demanding – as in any new scenario – new policies and institutions to contain and to steer actors’ behaviours as to optimize potential benefits and minimize transitional costs for all involved. In this context, the objective of the concept note is to introduce the bioeconomy concept, its drivers, and main areas of work and impact to help identify the themes were more socioeconomic analysis is needed in order, for society in general and policy makers in particular, to better understand and steer the emerging bioeconomy in the specific context of the Latin American and the Caribbean countries.

Currently society is facing a “more with less” food, energy and environment conflict scenario. Future needs will demand a significant production and productivity increase, but to address these needs, there will be increasing difficulties in relaying on existing practices, as current energy sources will become more scarce, hence more expensive, not to mention the negative environmental consequences that could be expected from a “business as usual” projection of present production strategies. This transition is, however, a gradual process involving substantial changes in many aspects, including both technological approaches as well as cultural and institutional structures, public policies and investment patterns. This scenario is not a new situation. The world has faced – and solved – similar dilemmas before. What is different this time is the scale and complexity of the needed action.

The bioeconomy concept based on the diversification and increased efficiency of natural resources use, is a response to the perceived challenges. Even though at present the potential competition between food and energy or other uses, may be seen as a source of

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1 Prepared by Eduardo J. Trigo, Director, Grupo CEO S.A., Buenos Aires, Argentina, as an input for the LAC regional IAAEA Inter-conference Symposium on the Bio-economy, 19-20 September, Cali, Colombia. The larger part of these contents is being discussed by the EC FP7 project ALCUE-KBBE (contract No. 264266). The results of the Symposium and continuing discussion, including this Concept Note, will be posted on the ALCUE-KBBE project website: www.bioeconomy-alcue.org

2 For the purpose of these notes the bioeconomy is understood as “the application of knowledge in life sciences in new, sustainable, environmentally friendly, and competitive products” (EC 2005), and «…..encompassing all those sectors and their related services which produce, process or use biological resources in whatever form » (German Bio-economy Council, 2010)
concern, in a longer term perspective – when all technical, institutional and policy transitions are completed – the bioeconomy most likely is a positive rather than a negative item in the balance. A first aspect that should be brought to bear in connection to the food security issue is that of the potential applications of biotechnology to increasing global food supply. A second one is that bioeconomy opportunities may be linked to nearly any kind of plant materials. As such bio-based industries are well suited for local production, and as engines for both rural development and income generation.

The policy and institutional dimensions are key elements in the transition from a conventional to a bioeconomy-based perspective. The common denominator of the emerging system is the increasing complexity of the new environment when compared to that of existing conventional food & fiber agricultural systems. An increased reliance on biomass-based processes and biotechnology as the knowledge base of economic activity brings up a number of other institutional changes that need to be addressed as well. These are linked to the nature of the science and R&D base, the logistics of the new systems, high investment requirements, the increasing importance of intellectual property (IP), biosafety regulatory systems, and standards and other market related regulations.

In this context the Latin American countries are well positioned both to contribute to and to benefit from the new bioeconomy. Their extensive and diverse natural resource base – land, water, biodiversity – and the fact that the region is also a prominent player in the early stages of the new biotechnology exploitation and the bioeconomy products – GMO crops and biofuels, are clear examples of this potential. In addition, ecologically intensive practices like zero-tillage, have been widely adopted especially in Argentina, Uruguay and Brazil. However, there are also a number of constraints that need to be highlighted and addressed if the bioeconomy concept is to be exploited for the benefit of the region’s people and making an effective contribution to current concerns regarding global environmental issues and perceived the food – energy conflicts. The relatively low levels of investment in both conventional and biotechnological R&D, as well as weaknesses in strategic policy areas, such as biosafety and intellectual property protection and natural resource management and promotion policies, are issues that need to be addressed.

Existing experiences indicate that the transition to a bioeconomy is a policy-driven process. Incentives, investments and regulations play a key role in triggering the new perspectives that are needed, and these will only be possible if all stakeholders develop a clear view of the objectives and benefits to be pursued and their role in bringing them about. As a first approximation, the type of socioeconomic research that will contribute to the development of the bioeconomy in the context of the Latin American and Caribbean countries could be grouped in three main areas. The first one is related to the generation of the information and the analyses aimed at improving the understanding by all stakeholders of bioeconomy related issues /opportunities / needs. Before options can be evaluated there is a need for an identification of objectives and the alternative strategies that could be implemented to achieve them. A second area of research should aim at providing the base for inducing the policy and institutional changes needed for promoting and facilitating public and private decision-making regarding bioeconomy developments. The third group of research activities includes the evaluation of the resource alternatives / technologies / regulations related to the specific bioeconomy product and market developments.
1. Introduction: the concept of bioeconomy

What is today referred as the bioeconomy, a concept which has been synthesized as “the application of knowledge in life sciences in new, sustainable, environmentally friendly, and competitive products” (EC 2005), or as “the aggregate set of economic operations in a society that uses the latent value incumbent in biological products and processes to capture new growth and welfare benefits for citizens and nations” (OECD, 2006), is a process emerging from a number of major, and convergent, drivers which make evident that for achieving the kind of objectives (for example the Millennium Development Goals) in terms of equity and poverty reductions and environmental and social sustainability, that both many national societies and the global community have set for themselves, the present natural resources use strategies can no longer be maintained and substantive changes need to be introduced, particularly in the direction of building a society much less dependent on fossil fuels than the one we have today. Some of these drivers are related to meeting expected demands and resource availability; others have to do with how modern science is modifying production possibilities in key areas of the economy.

In essence the bioeconomy is about moving economies based on petroleum and their derivatives to fuels and materials that are renewable, environmentally friendly and of greater availability. It is the coming together of modern biology and chemistry, materials sciences, and information technology to fully exploit the ability of plant materials and other living organisms. To capture solar energy and transform it in other forms of energy and products and eventually whole new value chains, with a reduced environmental impact, without sacrificing job creation, helping reduce poverty and continuing to improve the quality of life for a growing world population. In this context, the bioeconomy is about new ways of linking natural resources and processes to goods and services through increased knowledge intensity as a common denominator of the new value chains.

While previous cycles of modern economic organization and growth have depended on the exploitation of non-renewable sources of energy resulting from photosynthesis-based processes that took place millions of years ago, bioeconomy value chains are evolving from renewable processes of what could be called “real time” photosynthesis. This process is already underway and showing impacts in a wide array of application sectors, going from food and health to transportation, construction and, even, recreation. The greatest incidence has been until now in the health and pharmaceutical industries, where modern biotechnology is already widely used both in diagnostics as well as therapeutic applications generating a market that ranges in the tens of billions of US dollars a year. Plant biotechnology has become, over the 15 years since it reached commercial availability status, one of the more rapidly adopted technologies in agricultural history, reaching more than 120 million ha planted each year in more than 20 countries (James, 2010). Inspite of having been the centre of a fierce debate between those who promote the new technologies and those who oppose them, it is sustainably evolving to become the standard of agricultural industry rather than the exception, in a process that will probably gain strength as the idea of an much more diversified biomass-based energy and industrial matrix, gets established, linking both current and second generation biofuels, to the production of biomaterials including biopolymers and bio-plastics for the construction and engineering sectors.

More recently, in 2010, the German Bioeconomy Council, following the same line as the OECD 2009, defined the bioeconomy as «…. encompassing all those sectors and their related services which produce, process or use biological resources in whatever form”
The combination of conventional plant breeding with genomics and genetic engineering tools which allow the production of “high tech” plants designed to provide high biomass yields, with new “bio-refineries” which will be able to extract novel, value-added compounds, like fine chemicals, and convert the remaining biomass into energy or building blocks for chemical synthesis, leaving only small amounts of waste whose inorganic components could be recycled for use as fertiliser, will lead to new and more sustainable value chains, integrating green and white biotechnology, agricultural production, conversion technologies, materials sciences and other areas, many of which are developing and showing evidence of potential impact in diverse sectors, such as food, health, transportation and construction, among others.

Moving towards an economy of new competitive bio-based industries and value chains will not only demand a more carbon efficient and sustainable primary production and a more productive and resilient food chain, but also more effective innovation capacities and policies to mobilize the required knowledge base. Furthermore, there is an increasing belief that the knowledge base for many of the changes is already there. The issue seems not to be whether science can deliver; the technical feasibility of the new concepts has been, in most cases, proven. The limitations appear to be in the present level of understanding of the involved social and economic processes that accompany the emergence of the new sectors and ways of production, and questions regarding their implications, their costs and what are the policies and institutions that are needed to facilitate a rapid and equitable transition. A society less dependent on fossil fuels is a very different society than the one we know today, more decentralized, less dependent on large scale for efficiency, with different intersectoral –rural/urban – relations, and with different international trade relations – as a consequence of the changing balance in strategic resources. All this is leading to a new economic landscape (comparative advantages, country, sectors, products competitiveness), and is demanding – as any new scenario – new policies and institutions to contain and orient actors behaviours, so to optimize potential benefits and minimize transitional costs for all involved.

In this context, the objective of this note is to introduce the bioeconomy concept, its drivers, and main fields of work and impact to help identify the areas were more socioeconomic analysis is needed in order for society in general and policy makers in particular to better steer the emerging bioeconomy in the specific context of the Latin American and the Caribbean countries. In the remaining sections of the paper the discussion focusses first on the implications of current energy use strategies and the role that conventional and biotechnological approaches would have in the developments og the biotecnology, and then moves to address what these approaches could mean in terms of food security and rural development, the opportunities that could be opened for the countries in the Latin America and the Caribbean region, and what are the policy and institutional requirments for a full exploitations of the potential benefits offered by the bioeconomy. Finally, the last section looks into what are the themes in need of further socioeconomic research as basi for policy design and decision making with a bioeconomy development perspective.

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German Bio-economy Council 2010
2. The energy – environment conflict scenario

It is clear today that meeting the food and other products needs of a world population that is expected to reach nine billion people in the next 30 to 50 years, can hardly be done through a “business as usual” projection into the future of present day production practices. From different perspectives, there are many clear signs that the ways of the economy that emerged from the discovery of oil and the second industrial revolution are in need of revision.

Addressing the food and fibre needs of the future population in a sustainable way will require more than incremental changes (Federoff et.al. 2010). Available estimates point out that by 2050, when total populations reaches 9 billion people, food production may need to increase by as much as 70% (World Bank, 2007; Royal Society of London, 2009). This will have to be achieved in a context where productivity gains in the major staples have been falling for at least the last 25 years (annual growth in cereal yields worldwide has declined from about 3 percent in the 1960s and 1970s to less than 1 percent since 2000), good agricultural land is increasingly scarce, and other resources, such as water, are also becoming under threat.

Non-renewable fossil fuels – more precisely petroleum, gas and coal – have been the basic source of energy driving the world economy over the last 150 years. In effect, an endless list of products is derived from petrochemical processes and today most of agriculture, industry and modern transportation are dependent on oil based energy sources. There is no doubt that the “age of oil” has been one of the most prosperous periods in the world’s history, but over the last few decades, environmental concerns together with the progressive consolidation of tangible evidence that the future availability of oil resources may not be assured, have provided the base for an increased concern regarding both the environmental sustainability as well as viability of this high dependence of the world economy on oil and oil-based products.

On-going production and consumption patterns are showing environmental consequences at the local, regional and global scales. At the local level air pollution derived from transportation systems and industrial emissions have been a concern in every major city around the globe for quite some time and have prompted mitigation policies aimed at controlling emissions and improving air quality. At the regional level, adverse effects are also becoming visible in a variety of ways. Forest, land and waterbed degradation processes as consequence of the need to expand agriculture and / or inappropriate agricultural practices, are not only having adverse effects on current productivity, but are even raising questions about the mid-term sustainability of agricultural production (Cline, 2007). But it is at the global level were concerns are the greatest, as total CO₂ emissions are already starting to affect international equilibria. Specific damages have not been estimated beyond controversy, but there is a growing consensus that if current patterns are not reversed – not only by stopping emissions, but also having proactive sequestering actions – global climate will be negatively affected, changing almost every weather parameter, and significantly impacting human and animal habitats and productive activities. In more recent times, the rapid industrialization process of the emerging economies has meant a significant (structural) shift in world demand for both food and energy, which in turn has reflected on the current rise in commodity prices.
In sum, the challenge is clear: more with less. No matter how the numbers are drawn, meeting future needs will demand a significant both production and productivity increases – although it may be true that current agricultural production would be sufficient for existing population if equitably distributed, a still significant 50% would be needed to face the net increase in world population numbers. But to address these needs, there will be increasing difficulties in relying on existing practices, as current energy sources will become more scarce, hence more expensive, not to mention its negative environmental consequences. This transition is, however, a gradual process involving not only a change in the knowledge base, but also substantial changes in many aspects, such as cultural and institutional structures, public policies, investment patterns, among others. It could not be in any other way, given the magnitude of the processes and the diversity of social and economic issues and interests involved.

3. **New technologies and the bioeconomy: the role of biotechnology and the conventional approaches**

The type of conflict referred to above, is not new. The world has faced dilemmas like this one before. As a matter of fact, around 50 years ago, a similar conflict between rising population and stagnant food supplies led to concerns and debates like the ones going on today. At that time, the emergence of what got to be known as the “green revolution” (partially) provided the technological response to successfully increased production of a number of food crops to meet rising demand and avert an emerging food crisis. Improved plant varieties and a and more efficient input utilization – water, fertilizers, etc. – coupled, in some cases with new lands brought into production, provided for the additional output and a new higher level equilibrium (Echeverría y Trigo, 2008). These technologies, although still relevant for many environments, seem to be neither as potent nor as appropriate as they were two or three decades ago. Current productivity levels are getting dangerously close to genetic ceilings, water scarcity is a growing problem in many regions, where competition between residential and agricultural land use is becoming a more likely scenario. Furthermore, energy input intensification does not seem a coherent response in view of rising global climate change concerns, as high-input agriculture is – in many contexts – seen as one of the worst offenders in terms of CO₂ emissions. Even if this were not the case, energy scarcity – which is already manifesting itself as the continued rise in oil prices observed over the last few years – would make business-as-usual technological strategies, only a second best option. Quite to the contrary, agriculture, as the basic source of biomass has also become a key activity in the new emerging energy scenario.

Since experience has shown that the environmental impact of industry is directly proportional to the level of economic activity (i.e. if production doubles, so does its environmental impact), as production increases, so too must the environmental performance or eco-efficiency of implemented technology if concomitant increases in the environmental impact of industrial activities is to be avoided. What this means is that new technologies, which bring improvements in production, must do the same for eco-efficiency and for this, scientific and technological innovation, is essential.

Given the magnitude of the demands that are to be met, modern biotechnology, both in its applications to agricultural and to industrial production will certainly play a key role in
solving the emerging conflicts.\footnote{Biotechnology it is understood here as the array of techniques using living organisms or substances derived from these organisms to make of modify a product, improve plants or animals or develop microorganisms for specific uses (Cohen 1994).} \footnote{For an extensive discussion of the role of biotechnology in breaking-up genetic ceiling and improving food security through crop diversification see Gressel, 2008-a} Starting with the discovery of the structure of DNA, new developments in biology and, in more recent times, their interface with advances in information and communications technologies and the nano-sciences, are already creating a new scientific and technological environment within which input-output relationships can be rearranged, existing products and processes can be redesigned and, even whole new ones can be developed. Through the feasibility of changing the “limits” within which biological processes interact with natural resources – soil, water, solar energy – the new technologies are opening up a whole new range of opportunities not only in food, fibre and energy production, but in almost every sector of the economy, including pharmaceutics and industry in general. The consolidation of biotechnology as one of the dominant components of a new technological paradigm, will not only change the production function in a number of sectors and products, but it will also have effects in the production function of technology itself, as new scientific options mature, the efficiency and effectiveness of R&D processes are improved \textit{vis a vis} conventional approaches. This process is slowly making its way and new actors and institutions – legal and regulatory frameworks – are coming into play, reflecting the new scientific fields and the emergence of new markets, production and international trade patterns (Katz \textit{et al.} 2004), and there is no major argument that in the end, biotechnology will be the major element shaping future technological trajectories, both in agriculture and manufacturing industries.

In the more immediate future, however, it is quite unlikely that we can rely only on biotechnology, thus production and productivity increases will continue to come from conventional both animal and plant breeding improvements and improved chemical technologies, with more efficient resource use and agroecological considerations becoming increasingly important concerns. Rather than going from a “green” to a “gene” revolution, the more likely situation is one of technological “hybridization” and “blending”, with a shift from present day energy-intensive technologies to win-win alternatives that increase productivity while at the same time generating benefits in terms of natural resources management, or conservation technologies that integrally contribute to gains in agricultural productivity, with biotechnology having a much more important role in the tool-kit of research and technology development (“omics” and other molecular techniques), than at the product level. The difference between “traditional” (or conventional) and “modern” of technological environments becomes also less relevant as information and management technologies “blend” with biotechnological tools and traditional knowledge on the basis on location-specific requirements. Advances in this direction are already underway with ecological and environmental paradigms being incorporated in agricultural intensification efforts. The “sustainable intensification” strategy proposed by the Royal Society (RS 2009), and CIAT’s “eco-efficient agriculture” concept are but two examples of how this “hybridization” and “blending” process is evolving. In any case, what is clear is that the future is one of greater knowledge intensity, coming from both better exploitation of conventional and new biology-based approaches.
4. Food security and local development opportunities

The bioeconomy concept based on the diversification of natural resources use implies a potential competition between food and energy or other uses. This has been a source of concern ever since the concept started to be discussed, but it has intensified in more recent times as a consequence of rising food prices over the last two years and the emergence of social conflicts and food riots in a number of countries (Rulli y Semino, 2007). As oil prices have increased and bio-fuel alternatives have received increased attention throughout both the developed and developing world, the issue of bioeconomy’s impact on food security (access, availability, stability and resource utilisation) has moved to the forefront of the discussion. The importance of the issue is not under discussion, clearly food security is closely related to land use and if resources are taken out of food production and allocated to other uses, surely there is basis for the stated concerns, particularly for the poorer food importdependent countries, which are typically the most food insecure, given high dependence on imports of primary staple foods and exports of primary tropical commodities (FAO, 2008). Evidence, however, is not so clear as to whether biofuels are to blame for what has been happening in recent years. Recent studies seem to point out that biofuels, although important as demand-shifting parameters, are not the only factor behind the recent evolution in the agricultural commodities markets, as the combination of a number of poor years, stagnant technological change and thus, small yield increases and a the structural change in the demand parameters resulting from the full incorporation of a significant number of emerging countries’ consumers, seem also to be playing an important role. But even if the present tensions are to be related to the food vs. fuel / energy competition, in a longer term perspective, the bioeconomy is most likely a positive rather than a negative item in the balance sheet.

A first aspect that should be brought to bear in connection to the food security issue is that of the potential applications of biotechnology to increase global food supply. Until now, that potential has only been exploited in a very limited way and in relation to a handful of crops and traits – soybeans, maize, cotton, canola, herbicide tolerance, and insect resistance, among the most prominent. This is attributable to reasons more related to policy and institutional factors than to the actual lack of technological alternatives; a situation that may start to change as the current scenario of high oil prices/need for energy alternatives/food crisis environment, is processed at the international and national policy levels and the new technologies become more fully incorporated into the long-term crisis management strategies. Abiotic as well as biotic stress tolerance is already available at the platform level for many crops and fully exploiting them could not only make many of the resource competition issues being discussed today irrelevant, but also – as mentioned above – contribute to solve the poverty problem behind many of today’s food insecurity situations.

A second link between the emerging bioeconomy and food security, is that in many developing countries food insecurity is concentrated in rural areas and is a consequence of poverty and lack of opportunities, making any sustained progress in food security more related to new income generation than to food production itself (IICA (a), 2007). Bioeconomy opportunities may be linked to nearly any kind of plant material and as such, bio-based industries are well suited for local production, and as both engines for rural development and income generation. In developed countries, most of the available land is

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7 See: Trostle, R., 2008
already being utilized, but in many of the poorer regions of the world, the proportion of unused land is still significant and that could potentially be used for the cultivation of energy crops (IICA (b), 2007). Bioeconomy alternatives may bring to many areas a way out of the vicious circle of poverty in which many rural communities find themselves when their land base is not fit for highproductivity food crop production. The issue is to look beyond the present generation of plant-based energy alternatives, into strategies exploring more aggressively local biodiversity resources. In this sense, Henry and Trigo (2010) discussed the potential of small-scale alternatives and found that there is an ample spectrum of relevant opportunities for adding value at the local or on-farm levels related to bio-energy or feed stock production. Lack of electricity which is, in many cases, one of the critical restrictions for better market access and income generation in isolated rural situations, can be resolved through micro units fed with local biomass primary material, and/or subproducts (cassava, sweet sorghum, sweet potatoes, bananas and plantains, plant and animal residues and waste), thus creating better processing and conservations alternatives. Rural processing for “intermediate” product supply can resolve transportation and logistic restrictions facilitating local production linkages to large-scale factories (i.e. pre-processing of cassava for starch production factories). Biodiversity prospecting and valorisation in the form of identification of valuable functional components, as the basis for the development of appellation of origin systems, represent income generation opportunities that should not be overlooked. These and other alternatives are being successfully explored in different parts of the world. However, they are still highly dependent on different types of “pro-poor (public) policies” (in the form of targeted subsidies, investments, training, information, advice….), or “corporate social responsibility” policies by the private sector, for showing a high degree of insertion of small-scale actors (Henry & Trigo, 2010). The road towards the new bioeconomy calls for the mainstreaming of these experiences into poverty reduction and rural development strategies.

5. Policy and institutions for the bioeconomy

Both the policy and institutional dimensions are key elements in the transition from a conventional to a bioeconomy-based perspective. The application of new technologies, biotechnology in particular, to biomass production alternatives opens up a wide scope of potential benefits, yet at the same time raises a number of new issues that need to be clearly incorporated into the policy and institutional environments for those benefits to be effectively generated. Many of these issues are related to the particular characteristics of biotechnological applications and how they differ from conventional agricultural technology systems, but they also arise from the new and different ways in which the output of biomass production processes get integrated into the new value chains. They include aspects related to the comprehensiveness of the policies involved and the role played by policy in the necessary processes, the kind of science on which technology development is based and the type of institutions that are leading the process, the proprietary nature and investment requirements of the new technologies and the new regulatory systems, among other aspects.

The common denominator of the emerging system is the increasing complexity of the new environment when compared to that of existing conventional food/fiber agricultural systems. Table 1 summarizes the main contrasts that need to be considered (for a more comprehensive discussion of these aspects see Trigo 2002 and Trigo and Henry 2009)
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Table 1: Conventional vs. "Bioeconomy" oriented agricultural systems

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<th>Conventional food and fiber oriented agricultural systems</th>
<th>Bioeconomy oriented agricultural systems</th>
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<tr>
<td>- Predominance of agricultural and food security policies</td>
<td>- Policy environment integrating natural resources, food and agriculture, energy and industrial development dimensions</td>
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<tr>
<td>- Predominance of public good / strong participation and leadership from public institutions as drivers of new technological concepts</td>
<td>- Strong participations and leadership from the private sector in technology development</td>
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<tr>
<td>- Agronomic and applied sciences</td>
<td>- Technological applications closely linked to basic research</td>
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<tr>
<td>- R&amp;D most oriented to food production-productivity-quality related issues</td>
<td>- Horizontal R&amp;D systems (“beyond food”-natural resources use- value chain issues)</td>
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<tr>
<td>- Relatively low investment requirements</td>
<td>- High investment requirements</td>
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<tr>
<td>- “Weak” intellectual property systems</td>
<td>- “Strong” intellectual property protection systems</td>
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<tr>
<td>- Low regulatory intensity</td>
<td>- High regulatory intensity</td>
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<tr>
<td>- Predominance of bulk marketing and logistical infrastructure, low product differentiation except for quality standards.</td>
<td>- Biosafety</td>
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<td></td>
<td>- Consumer protection</td>
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<td></td>
<td>- Increasing importance of value chain integration, product differentiation and standards, and market segmentation issues</td>
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Source: The author; and on the basis of Trigo (2002)

The policy environment. In terms of policies, the main contrast is in the policy focus and the type of instruments involved. Traditional agricultural policy instruments need to be adapted to the different life cycles implied in the bioeconomy. In the “conventional” food and fibre sectors we are essentially confronting “mature” stage situations. In the bioeconomy, most cases are in the early phases of the introduction stage and in need of, on the one hand, incentive policies to attract and guide investments into the sector and on the other, sustainability instruments to assure good practices in natural resources management and preserve food – energy/other uses balances. A bioeconomy policy environment needs to explicitly consider the natural resources/environment, energy, agriculture, industrial and trade policy domains. The experiences of Brazil, the EU and the US with regulations and tax and market incentives aimed at the development of modern biofuels, are clear examples of how important the structure of these and other policies are to shape the direction of the new industries and their markets (EU example: Lead Market Initiative). A real transition towards a more comprehensive bioeconomy approach will require however, a more complex policy mix, including feedstocks, input diversification, land use planning and industrial and consumer level – fair trade, sustainability and “green” certification, etc. – policies, reaching beyond the energy/transportation sector. In this sense, policies must be enacted to protect threatened lands, secure socially acceptable land use and steer bioenergy development in a sustainable direction to avoid environmental and social damages. At the primary sector level, agricultural policy, including the availability of rural infrastructure, credit and land tenure will determine the scale and distribution of economic benefits.

Action at the policy level, however, will not be enough. An increased reliance on biotechnology as the knowledge base of economic activity brings up a number of other institutional changes that need to be addressed as well.

The science base. The discovery of rDNA and the principles of genetic engineering (i) evolve from a close interaction among a number of the basic scientific disciplines (biology, genetics, biochemistry and chemistry, physiology, etc.) and (ii) are applicable across a broad range of subject matters in the areas of health, environment, manufacturing industry and agriculture. Biotechnology capacities are of a generic nature and its natural
institutional environment is that of the basic sciences which usually have no operational links to existing agricultural technology delivery systems. It is true, that once the new genetic constructs are available, for them to be of any economic value there is the need to backcross them into the broad germplasm basis of existing commercial varieties and undertake the large-scale field evaluations to adapt the new products to local ecological conditions and cultural practices. Farmers will not adopt them, unless they are packaged in a genetic platform with acceptable production and productivity performance. But the development of the innovation itself (the discovery of the new genes, markers, functions, etc.) needs not to be formally integrated with downstream technology development activities. These characteristics have direct implications in terms of the structure of interactions between basic and applied research organizations, as well as with respect to the diversity of the institutional actors involved and, in turn, for science and technology policy making. Science and technology investment levels, inter-institutional collaboration, including public-private joint ventures, among others, become key elements that need to be recognized and directly addressed if an appropriate environment for effective biotech R&D system is to be set in place.

**High investment requirements.** Even though there is increasing evidence that the costs of biotechnology research have been steadily decreasing over the last decade or so, biotechnology-based development is an expensive undertaking. For instance, some estimates place the total cost of placing a new GM product in the market, considering both the R&D and the regulatory process, in the US$ 50 – US$ 100 million range. This issue is fully supported by the scattered information that exists about R&D investment levels by some of the leading firms in the business. According to the OECD (2009) the seven largest multinational companies in the field were investing in biotechnology related R&D over USD 1.85 billion, with the largest of them – Syngenta – investing an estimated USD 510 million a year. For most developing countries – with the exception of, maybe, China, India and Brazil – this type of investment requirements are out of the question and, definitively, a major hurdle for the exploitation of the full potential of the new technologies. This is even more so if one factors in the relatively long maturity time of required investments vis-a-vis the short-term perspective and instability of investment trends that characterize most of the developing world Science & Technology systems.

**The increasing importance of intellectual property (IP).** The emergence of biotechnology brings about a noticeable displacement of the "technological space" in the direction of the private sector. While public goods tend to dominate the traditional agricultural technology research and development policy and organizational systems, in biotechnology, proprietary technologies are the rule rather than the exception, demanding both a revision of the IPR systems, as well as increasingly more complex management requirements for R&D processes. An indicator of the important of IP in general and of patents in particular, is what has been happening in the area of biofuels, where in the last 6 years, 2,796 biofuel-related patents have been filed, 1047 of them (a seven fold increase from the 202 number) in 2006-2007. IPR regulations are a critical component of the overall investment environment, as they will not only set the stage for R&D investments in

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8 “Innovando para el Futuro” ppt presentation by Dr. Robb Fraley, Chied Technology Officer, Monsanto Corp, USA, 2008.  
9 OECD 2010.  
10 [www.bakedaniels.com](http://www.bakedaniels.com). The term “Patents” refers to US patent applications, PCT international applications and granted US patents published up to Nov. 2007.
any given country, but also condition its ability to access technologies originally developed for other environments.

The IP issue is of relevance not only regarding the new technologies, but also—and, probably in the LAC context, even more relevant—in connection with genetic and biodiversity resources. It is clear that biodiversity resources are one of the strengths of the region in regards to the bioeconomy, however, there is little yet in terms of the application of the still evolving and complex institutional and regulatory framework being developed to regulate access and benefit sharing. While many of the countries are active in the Convention of Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture, still at the national level there is little in terms of concrete mechanisms needed for the effective transformation of potential into actual benefits.

Policies in this respect need not only consider the promotion of private involvement in research and development activities, but more global issues related to the creation of the appropriate environment for greater direct domestic and foreign investment biodiversity-valorisation business development activities.

**Biosafety regulatory systems.** There have been both concerns and controversy about the potential environmental and human health risks since the very early stages of development of biotechnology, with a concrete focus on GM plants.11,12 Because of these concerns and controversy, initiatives directed to minimize eventual environmental and public health risks, through biosafety regulatory processes, have evolved pari passu with the development of biotechnology tools and products, as an integral part of the R&D and investment policies in the sector. From the point of view of the development of the bioeconomy, biosafety is a key issue, not only linked to present day biotech applications and because the bioeconomy applications of many plant materials—i.e. for bio-fuel production—are highly dependent of genetic engineering for their full adaptation to the new uses, or production environments, but also because one should expect a greater move towards developing, testing, distributing, and cultivating crop species in environments where their potential economic and, particularly, social and environmental benefits are still largely unknown.13

Biosafety regulations are, by nature, complex and lengthy, probably representing the single most time-consuming segment of activities in the process of discovery and development of a transgenic crop variety. These problems are further extended by a tendency to increase the number of studies and the amount of information that many national regulatory bodies are requiring as part of the risk evaluation process and the fact that many systems include a large share of political discretionary decision-making power regarding the final approval of a given event, generating a high level of uncertainty regarding the final outcome, thus adding to the costs of product development. This is proving to be of particular importance for smaller countries as it impinges on their ability

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11 When talking about environmental, food safety and consumer acceptance issues, we are essentially referring to genetic engineering techniques and GMOs, as the other main techniques (tissue culture, diagnostics and genetic markers) raise few serious questions dealing with biodiversity, consumer or ethical concerns.

12 For comprehensive information about biosafety issues see: [http://binas.unido.org/binas/home](http://binas.unido.org/binas/home)

13 For a full discussion of the role of genetic engineering in crop development for biofuels and the role of biosecurity in the new bioeconomy, see Gressel 2008 and Sheppard *et al.* 2011.
to free ride on external R&D and capture spill-in benefits. These tendencies also discriminate against national public research institutions and national firms and their ability to become active players in product development – for instance, in biodiversity valorisations initiatives. Having –usually- a weaker financial position than large multinational corporations, is more difficult for them to bear the additional costs involved.\(^{14}\)

**Standards and other market-related regulations.** Standardization is a key issue for the development of the bio-based products market. Standards are essential elements in aggregating initial demand and allowing effective communication among agents within a given market and across connected markets. They are the basis for market transparency by providing common reference methods and requirements in order to verify claims about these products (e.g. bio-degradability, bio-based content, recyclability, sustainability), and to guide investment and other related economic decision-making. In general there is a lack of standards linked to bio-based products, both at the national and international levels, in particular in what is concerned with the determination of bio-based content as well as other product capabilities including functionalities, the evaluation of environmental impact, and a number of other purposes.

6. **Opportunities and constraints for the development of the bioeconomy in Latin America and the Caribbean**

In this context, Latin American countries are well positioned, both to contribute and to benefit form the new bioeconomy. Their extensive and diverse natural resource base – land, water, and biodiversity – provides them with one of the essential components for a solid bioeconomy strategy. This is already becoming evident in the field of biofuels, where the region is a key global player and projections to the year 2050 indicate that this role will strengthen rather than weaken, as the region is the only area of the world with the capacity to meet both its domestic demand and contribute to global equilibria. At the same time, its biodiversity endowment provides a key base for the diversification of bio-processes’ feedstocks, and as a greater variety of plant and other resources become established alternative sources of raw materials and inputs for biofuels and other new value chains, there is the potential for improved income opportunities and through that, bettering the economic and social conditions of specific local communities.

Latin American countries can also boost internationally recognized experiences in some of the ecological intensification practices, especially zero-tillage. This practice has been gaining force since 20 years and today is widely adopted in Argentina, Uruguay and Brazil (Trigo e.al., 2009).

The region is also a prominent player in the early stages of biotechnology exploitation. GMO technologies – herbicide tolerant soybeans and insect-resistant and herbicide-

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\(^{14}\) Even though, as indicated, there are no good estimates of the actual costs of putting a new product through the regulatory process, a simple calculation can provide an idea of how stringent this cost may become for smaller companies and organizations. If one takes, as a basis the usual 10-12% discount rate used for project evaluation, if the approval for commercialization takes more than 5/6 years, regulatory costs –considering only the cost of having capital immobilized and not the direct costs that may be originated in the regulatory process itself– become the largest component of the total cost, no matter what may have been the actual research costs of developing the innovation.
tolerant maize and cotton – were introduced in different countries of the region almost at the same time of their commercial availability in the international markets. Out of the 29 countries in the world that, as of 2010, are using GM technologies today, ten are Latin-American, and four of them (Brazil, Argentina, Paraguay and Uruguay), are currently planting more than a third of the total world area with GMOs, are among the ten largest producers (James 2010).

The above mentioned advantages are significant in key components of the bioeconomy: natural resources diversity and knowledge management. However, there are also a number of constraints that need to be highlighted and addressed if the bioeconomy concept is to be exploited for the benefit of the region’s people and for making an effective contribution to current concerns regarding global environmental issues and the perceived food vs. energy conflict.

The high intensity of use of biotechnological applications in the region’s agricultural sector is, indeed, a great advantage, for what it means in terms of the logistical and field experience needed for the effective handling of one of the strategic components of the new production strategies, but a closer look at the situation shows that regional science and technology systems have had little to do with this, as most of the innovations involved have come from outside the region and domestic investments both in science and technology in general and in the biotech related fields in particular is dismally low (Trigo, Falck-Zepeda y Falconi, 2010). Up to 2007, 82% of the field trials of GM crops and 100% of the varieties in the field, were technologies generated outside the region, reflecting not only the low levels of investments in biotechnology research – about USD 130 million, or about a fourth of the investments of the largest multinational corporation, for the whole region – but also significant levels of underinvestment in conventional agricultural research (ASTI).

Other constrains include weaknesses in strategic policy areas, such as biosafety and intellectual property protection – two key areas given the novelty of the technologies and the proprietary nature of most of the knowledge base involved – and natural resource management and promotion policies. Besides being knowledge intensive, the bioeconomy, at this stage, is policy-driven and, in most of the countries, there is very little of the latter. With the sole exception of Brazil, policies in most countries are, at best, patchy and restricted to biofuels for the transport sector. In most cases, they encompass some biofuels incentives and broad regulations, but hardly anything that could be taken as a long-term framework, taking into consideration all dimensions involved (food security considerations, energy alternatives, science, technology and innovation, spatial and rural development, natural resources, market development, trade implications, etc.)

Furthermore, the region shows a chronic lack of reliable and updated basic data on agricultural systems, practices, markets, private/public research and perhaps, even more important (maybe as a consequence of that deficiencies), analyses of the fast changing dynamics of agricultural systems and value chains.

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15 The situation is even worse if desaggregated by country. In both cases about 50% of total investments are in Brasil and the five largest countries (Brasil, Argentina, Mexico, Colombia and Chile) account for more than 85-90% of total investments (Trigo, Falck –Zepeda y Falconi, 2010; ASTI)
7. **Towards a socioeconomic research agenda for the bioeconomy in LAC**

As discussed above, it is evident that Latin America as a region has a wide range of opportunities to exploit in the framework of a bioeconomy development strategy. The diversity of its natural resources is an advantage which offers a great potential, both for integrating bioeconomy products into the international economy and also exploiting them for improving the environmental footprint of the economies and fostering the well being of local communities and rural development. These advantages also confront a number of constraints that need to be addressed before effective progress can be made. Beyond the weakness of the regional science and technology systems, the most important element limiting future developments is the fact the idea of the bioeconomy is still not recognized as a relevant alternative, and consequently there is little in terms of public policies and the establishment of an institutional environment to attract the needed investments from the private sector in a sustainable, long-term basis.

Awareness, regarding what makes the bioeconomy an alternative and, particularly, of its opportunities, is a key element for its future development in the region. What can represent the bioeconomy in the LAC context becomes a relevant and decisive question in this sense. Existing concepts and discussions have evolved from either global concerns – feeding nine billion people, climate change, future energy scarcities, etc. – and what they imply for given resource endowments, such as the case of the European countries. It is clear that, even within the general principles discussed in the earlier sessions of this note, both the objectives and the emphasis of the particular strategies to be followed will be quite different for a situation such as that of the Latin American and the Caribbean countries, than those pursued in other environments. The relative weight of the different objectives as well as the time frames for action, need certainly to be adapted to reflect the particular characteristics of the resource base and the nature of the social objectives relevant to the region. Given its resource base, the LAC region has a very particular role to play in global food security; at the same time poverty alleviation and rural development aspects need to be taken up from a very different perspective from that of the European context, or, for that reason, the context of any other region of the world. The first step toward the emergence of a LAC bioeconomy, is the clear understanding of its implications. Only when the objectives become clear it would be possible to move into the specifics of the strategies and the resources that need to be mobilized to achieve them.

A bioeconomy implies a substantive change in natural resources use, both in terms of the how they are used and for what they are used for. The most prominent new conflict in the region is the food-energy one, but there are also other dimensions that need to be considered. Natural resources, agricultural, rural development and energy policies must be integrated and evolved out of a better understanding of the anticipated effects of changes in land and biodiversity management practices, the price effects from shifting the focus from agriculture to energy crops and the subsequent need to deal with the eventual social and economic impacts of these changes, both on local communities and economy-wide.

The bioeconomy, as it was mentioned earlier in these notes, is policy driven. Incentives, investments and regulations play a key role in triggering the new perspectives that are needed, and these will only be feasible if all stakeholders develop a clear view of the benefits and their own role and responsibility in bringing them about. Policy makers are key actors in this process, but the need for awareness goes all the way down to the local
communities, as many of the benefits will only materialize if macro-level actions find local capacities ready to take advantage of the opportunities that will arise.

Knowledge management issues are another key aspect to consider. Knowledge is the essential input of the bioeconomy. Biotechnology, probably, the most prominent of its components, but –as it was emphasized above – it goes beyond that. All sources of knowledge need to be brought into play as coherent and complementary components in a paradigm shift. Human resources issues and the institutional and management systems to access and make available at the local level the needed knowledge base, are key elements to develop in support of the emerging bioeconomy.

Finally, there are the actions at the micro level, putting new approaches at work in the production of specific products and services; implementing new technologies and setting the stage for the creation of the new value chains. The private sector will play a central role at this level, as investments and logistics are the key drivers at this stage. Furthermore, large chunks of the relevant knowledge and derived technologies are proprietary, making public-private interaction and the creation of new knowledge-based enterprises essential to any successful policy strategy.

Each of the areas /issues identified here are in need of scientific, technical and socioeconomic research and information generation. As a first approximation, table 2 summarizes the type of socioeconomic research that will contribute to the development of the bioeconomy in the context of the Latin American and Caribbean countries. Research areas are grouped into three broad categories aimed at a better understanding of what the bioeconomy has to offer and what, in turn, needs for its development, the types of policies and institutional changes that are needed for its emergence, and micro-level information needed for investment decision-making linked to the development of the new value chains by the different economic agents active in both the production and marketing sectors. The importance of the different types of research is presented in general terms, independently from the particular mix of specific actions / policies / institutional changes that any given country needs to implement. The type of instruments to be applied, however, will, in the end, depend on the specific natural resources, scientific and human resources capacities, and how proactive that particular society will turn out to be with respect to the promotion of the new approaches.

This 2nd version of the concept note includes a Table 2, that was modified based on an in-depth analysis and discussions during the second day of the Symposium.
Table 2: Types of socioeconomic research needed to mobilize / back-up public and private decision making regarding bioeconomy development in LAC

<table>
<thead>
<tr>
<th>Areas where actions / policies is needed</th>
<th>Objectives</th>
<th>Socio-economic research targeted at</th>
</tr>
</thead>
</table>
| Improving the understanding by all stakeholders of bioeconomy related issues /opportunities /needs | Making the bioeconomy model known at all levels and establishing a base for the definition of a “bioeconomy for LAC” concept (objectives, components,……), including what role the region plays within the emerging (global) bioeconomy | - Explaining the bioeconomy vis a vis other related concepts, i.e. eco-efficiency, green economy, low carbon economy, sustainable development)  
- Identifying how the global drivers reflect in the LAC situation  
- Valuing LAC resources in the bioeconomy context  
- Documenting key bioeconomy implementation cases to highlight specific characteristics / opportunities /impacts (different resources, processes, countries, links to the local, national and global economies, etc.)  
- Identifying and estimating the potential bioeconomy benefits for LAC countries  
  - Macroeconomic impacts  
  - Trade implications (benefits / restrictions)  
  - Impact on employment of bioeconomy alternatives  
  - Food security implications (global, regional, country and local level)  
  - Implications for resource use (land, water) and rural  
- Establishing the basis for a reliable set of bioeconomy-related economic and social indicators (GDP share, industry value, employment, business development, markets, trade; resource use efficiency and productivity; climate change and other environmental variables. |
## Mobilizing policy and institutional changes aimed at promoting and facilitating public and private decision-making regarding bioeconomy developments.

### Identifying needed policy and institutional developments / reforms.

1. **Related to the innovation systems for to the bioeconomy**
   - Foresight and scenario analysis (food security, climate change, energy, poverty reduction, …) for the development of the bioeconomy for different regions / resources / products.
   - Critical factors affecting innovation processes (economic incentives, R&D capacities, human resources, intellectual property and other regulatory systems, …).
   - Economic and impact assessment of new technology options (ex-ante + ex-post)
   - Constrain affecting the emergence and competitiveness of bio-based product markets (technical, investment, logistical, regulatory, standards, national, international, consumer preference / behavior).

2. **Policy and institutional constraints**
   - Analysis of impact of specific bioeconomy components / issues (land use, alternative feedstock, biofuels, biorefineries, bio-based value chains) on food security, climate change, rural development, employment, local environment, ….
   - Governance, pricing, regulatory and trade issues of existing and prospective markets for bio-fuels and bio-based products in general.
   - Resource use efficiency of bioeconomy vis a vis conventional approaches.
   - Gap analysis in policy domains relevant for the development of the bioeconomy (R&D, investment, human resources, energy, food security, …).
   - Development of appropriate metrics for specific policies, markets and industries.

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| Evaluation of specific resource alternatives / technologies / regulations. | Generating relevant information for bioeconomy project / product / market developments. | • Life cycle analysis of bio-based products, technologies and value chains.  
• Local level impact of different biorefinery models (income, employment, food security)  
• Evaluation of competitiveness, market potential, impact on employment levels and other structural effects of different bioeconomy related technologies pathways. |
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