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Landscaping a Biofuture in Latin America

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Content

Introduction

Over the course of the last decade, references to a bioeconomy have steadily grown in relevance, ranging from institutional discourses involving international actors and agencies to the formulation of national strategies and securing its role in wider agendas, such as the 2030 *Sustainable Development Goals (SDGs)* and global climate change policy.[1]

It is difficult to pinpoint an exact definition for the term *bioeconomy.* In its ever more frequent usage, it often, and to a great extent, shares common traits with what is referred to as a circular, green or low-carbon economy[2], each employed alone or combined depending on the relative emphasis on certain aspects or different contexts. As a concept, the bioeconomy is not new. By the end of the 20th century, the term was limited almost exclusively to academic debate, but it started to gain prominence and enter policy discussions through the application of "bioeconomic models", the use of mathematical calculations to administrate quota management systems over limited natural resources, for example, in fisheries. This phenomenon was rooted in a broader social and political change occurring in environmental policy at the time, which combined the rise of ecological economics with neoliberalism. Since then, the term has spread far beyond natural resource management, has been incorporated into many other fields, and its use redefined. The most relevant thread follows how the term was steadily incorporated into the development and innovation debates in Europe during the 90s.

In the 21st century, the term *bioeconomy* has gained increased importance in the discourse led by institutional actors, starting to appear within the context of national and regional strategies. Germany was a pioneer in this debate with the creation, in 2009, of a *National Council on Bioeconomy,*[3] which formulated regional roadmaps and a national strategy (released in 2010 and updated in 2012) to include sustainable energy.[4]

Landmark documents that punctuate the international process include the OECD's (2009) *The Bioeconomy to 2030: designing a policy agenda*[5]*;* the European Commission's (2012) *Innovating for Sustainable Growth: A Bioeconomy for Europe;* and the United States' (2012) *National Bioeconomy Blueprint.*[6]

While the growth of the bioeconomy can be largely attributed to biotechnology through the development of foundational technologies, such as genetic engineering and DNA sequencing, tomorrow's bioeconomy relies on the expansion of emerging technologies, such as synthetic biology (the direct engineering of microbes and plants), proteomics (the large-scale study and manipulation of proteins in an organism), and bioinformatics (computational tools for expanding the use of bio-

Threshold of a previously unimaginable future....

"Decades of life-sciences research and the development of increasingly powerful tools for obtaining and using biological data have brought us closer to the threshold of a previously unimaginable future: "ready to burn" liquid fuels produced directly from CO2 , biodegradable plastics made not from oil but from renewable biomass, tailored food products to meet specialized dietary requirements, personalized medical treatments based on a patient's own genomic information, and novel biosensors for real-time monitoring of the environment. Increasingly, scientists and engineers are looking to augment biological research with approaches from other scientific disciplines for solutions to our most demanding scientific and societal challenges and seeing exciting options that will profoundly affect our future".

National Bioeconomy Blueprint (2012), p. 15

1 Communiqué of the Global Bioeconomy Summit. *Making Bioeconomy Work for Sustainable Development* (2015); available at http://go.nature.com/293zhq2

2 https://www.tni.org/en/publication/the-bioeconomy

3 http://biooekonomierat.de/

4 The German strategy focused on obtaining a better understanding of the elements and structures of biological systems, e.g. algae, enzymes, and micro-organisms, covering a vast area that includes sectors such as health/medical, industry (fine chemicals and bioplastics), agriculture (pesticides and feed supply), and environmental services. Albrecht K. and Ettling S. (2014) *Bioeconomy strategies across the globe.* Rural 21, Vol 48 No. 3/2014

5 The report was developed through the OECD *International Futures Program.* The process to produce the *Bioeconomy 2030* report was launched in 2005 under a strong political imperative: *"When OECD science and technology ministers met in Paris in 2004, they urged the OECD to strengthen its contribution to work on biotechnology as a driver for sustainable growth and development. In particular, they encouraged the Organization to complete its work on the policy challenges for a biobased economy, and to identify the barriers to and opportunities for its further development".* http://www.oecd.org/sti/biotech/34823102.pdf / http://www.oecd.org/futures/long-termtechnologicalsocietalchallenges/thebioeconomyto2030designingapolicyagenda.htm

6 Modeled after the Obama Administration's 2011 *Blueprint for a Secure Energy Future* https://www.whitehouse.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf

logical and related data), as well as "new technologies as yet unimagined".[7]

In addition to its potential to spur growth, the bioeconomy is promoted as a way to offer wide societal benefits: longer, healthier lives; reduced dependency on oil; addressing key environmental challenges; transforming manufacturing processes; and increasing the productivity and scope of the agricultural sector while growing new jobs and industries.

Much beyond sectoral policies or strategies, the bioeconomy entails a technological and political agenda for the future.

7 *National Bioeconomy Blueprint* (2012), p. 15

1 Into the biofuture

In general terms, a bioeconomy includes all extraction of, and production from, renewable biological resources, i. e. all value adding activity connected with biological resources encompassing the agriculture, forestry, fisheries, food and biotechnology sectors, as well as a wide range of industrial sectors, ranging from the production of energy and chemicals to building and transportation.[8] Specifically speaking, goods and services in a bioeconomy include those resulting from the use and transformation of biological resources and the utilization of waste, e. g. biocides and bio-fertilizers (and other inputs used in agriculture), biomaterials (and other manufactured products, such as bioplastic products), bioenergy (biofuels from first and second generation fuels, to biogas and bio-solar energy), biofortified functional food (and other products from the food industry), biopharmaceuticals and biomedicines in general (including personalized medicine), bioservices, based on the use of environmental services linked to the landscape, as well as financial bioservices linked to the mobilization of financial resources associated with the bioeconomy (including emission markets, be they local or global).[9]

Emerging as a new *vision for the future of society*, the bioeconomy is presented as a strategic cornerstone in a major global transformation of the global production system; a paradigm shift able to reshape the development discourse in the 21st century and spur green, sustainable, low carbon and smart growth.[10]

The bioeconomy is promoted by the mature economies of *developed* countries as an opportunity for re-industrialization led by a *knowledge-based bioeconomy (KBBE)* where the role of intellectual property rights is key to innovation. To this end, the fusion of life sciences, biotechnology, information technology, and Big Data could transform and add value to sectors as diverse as energy, agroindustry and nutrition, chemicals, and health, creating a wide range of bio-based raw materials, reshaping global value chains as markets and demand for bio-based products are created.

In tune with its breadth and scope, the transition to a bioeconomy is often compared to a "third industrial revolution".

Regardless of whether it is ecologically, socially, or technically feasible, the idea of a great transformation in the making and on a global scale mobilizes political imaginaries and discourses in a very fundamental way.

In this sense, the bioeconomy works as a "futuring" strategy. The effort to make the bioeconomy idea a reality, to develop *"the concept of the bioeconomy to its practical delivery on the ground"*[11], betting on a vast, yet untapped, potential to be realized through technology, is one of the key concerns for mature economies in the Global North. *"An innovative bioeconomy is vital for the re-industrialisation of Europe and could produce 1.6 million new jobs by 2020 and 90,000 by 2030 in the maritime and biobased chemical sectors alone."*[12] At the same time, the decarbonization agenda is being promoted as a means to generating European re-industrialization with job creation from building retrofitting to technology and innovation development, including related new research areas and teaching at universities – all in line with the first target of the *Europe 2020* agenda: *"75 % of the 20–64 year-olds to be employed"*.[13]

The "futuring" effect of the bioeconomy is present in the Global South in distinct contexts and in the mobilization of political imaginations. It has been deployed to reboot and legitimize agribusiness strategies (in Brazil and Argentina), and to renew political discourses, for example, by highlighting the role biodiversity can play as a strategic resource to qualify a country as a player in an upcoming global transition towards the new paradigm of the bioeconomy. Colombia's President *Juan Manual Santos*, affirming that *"the next great revolution is biotechnology"*, is suggesting that the end of the country's decades-long conflict brings with it the opportunity to consolidate a bioeconomy for Colombia, opening the doors to scientific researchers by allowing them into territories that were previously inaccessible, so that they can explore with more rigor

8 *"Innovating for Sustainable Growth: A Bioeconomy for Europe"* (2012), defines the bioeconomy in a broader sense than the OECD definition.

9 CEPAL 2015. http://conferencias.cepal.org/Conferencia_bioeconomia/

10 *Europe 2020: "The strategy is about delivering growth that is: smart, through more effective investments in education, research and innovation; sustainable, thanks to a decisive move towards a low-carbon economy; and inclusive, with a strong emphasis on job creation and poverty reduction."* http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/priorities/index_en.htm

11 http://europa.eu/rapid/press-release_MEMO-14-568_en.htm

12 http://biconsortium.eu/news/launch-european-bioeconomy-observatory-pilot-website

13 *Europe 2020* is the European Union's ten-year job and growth strategy. Launched in 2010 to create the conditions for *"smart, sustainable and inclusive growth"*, it is a key roadmap for moving decisively beyond the crisis and creating the conditions for a more competitive economy with higher employment.

the opportunities offered by the biodiversity and the *"enormous economic development potential"* of plants, micro-organisms, and genetic diversity as an alternative path to growth in Colombia.[14] In this vein, Colombia and the UK announced a £ 20 million bioeconomy cooperation agreement and joint research program in the context of the Peace Process in late 2016. The program will tap into economic and scientific opportunities in Colombian regions affected by conflict to develop new drugs, medicines, and biofertilisers that can sustainably increase crop yields across the country, as well as products that tackle pollution, thus *"addressing developmental issues and global challenges, such as halting deforestation, and unlocking the full potential of Colombia's biodiverse geography"*.[15]

Brazil, amidst maybe the most serious economic recession in its history and an unprecedented institutional crisis following the impeachment of *Dilma Rousseff*, has used the international stage offered by the latest round of climate negotiations at the COP 22 in Marrakech to take a leading role in heading a coalition of countries as they launch a global *Biofuture Platform*.[16] Upon its launch, the platform included the following members: Argentina, Brazil, Canada, China, Denmark, Egypt, France, Finland, India, Indonesia, Italy, the Netherlands, Morocco, Mozambique, Paraguay, the Philippines, Sweden, the United Kingdom, the United States, and Uruguay. The intention is to gather *"the most relevant countries for driving of markets and innovation in advanced biofuels and biomaterials"*. Germany is not yet a member.

Ethanol is an important element in the hemispheric geopolitical concerns regarding energy security, and a bilateral agenda between Brazil and the US has been in place since 2007 when Presidents *Lula* and *Bush* sealed what was dubbed the "ethanol alliance".[17] In the years that have since followed, the subject has been eclipsed in Brazil by the discovery of Pre-Salt (massive offshore oil reserves) and a mix of factors that have impacted the ethanol sector and downplayed its perspectives for international trade; in global terms, the agenda addressed an overall criticism of the early biofuels boom. The opportunity to relaunch the biofuels agenda, rebranded under the "sustainable transport" agenda and not as "renewable energy", reflects Brazil's intent to be a global player with second generation fuels.

14 26/09/2016 http://www.elespectador.com/noticias/medio-ambiente/bioeconomia-proxima-revolucion-de-colombia-articulo-655255

15 02/11/2016. *"At the conclusion of the Environmental Serial, President Santos was gifted a picture of a new species of ringlet butterfly, Magneuptychia pax (the 'Peace Butterfly'), named in recognition of the ongoing peace process work taking place in Colombia. The new species was discovered in the Amazon and described based on a study by an international team of experts, led by Dr. Blanca Huertas Senior Curator of Lepidoptera at the Natural History Museum."* https://www.gov.uk/government/news/uk-colombia-agree-new-20-million-bioeconomy-research-programme

16 https://www.biofutureplatform.org/

17 http://climateandcapitalism.com/2007/03/13/united-states-and-brazil-the-new-ethanol-alliance/

2 Bioeconomy in context: reframing the development discourse

In a carbon-constrained world, old style, fossil-fuel-based industrialization is not a viable option. National "development" led by heavy based and fossil fuel dependent industrialization strategies – in the sense of developing an industrial park – is just not a realistic path to pursue in a globalized economy, presenting a key challenge on how to create "green" jobs in order to transition to a bioeconomic workforce. In this context, mainstreaming the bioeconomy has been instrumental in reframing the development discourse. From a long-term perspective, if we consider other transformation processes that occur in the global economic production system, such as mechanization, mass production, and electrification, none of these transformations appear regular and ordered.[18] In relation to previous moments in history, the current challenge is that climate protection targets are superimposed onto a "development" process. A common future, where there is a commitment to "leave no one behind", offers a safety rail of goals, targets, and indicators embodied by the SDGs that comprise the 2030 agenda for Sustainable Development. In addition, "development", what should in principle be the unfolding of an open, future-oriented path with no predetermined formulation, is bound by the first-ever universal, legally binding climate agreement in the shape of the Paris Agreement, with all countries under the common metrics of climate change, CO_2, and emissions accounting.

In this context, the current bioeconomy transformation is framed within this larger package. As the world moves from a hydrocarbon to a biomass-based economy, the scale and content of this envisioned shift set to take place over the course of the current century poses new questions and fundamental challenges to the role countries and regions will play in this biofuture in the making.

Designing an industrial policy in a globalized world

A key characteristic of the current stage of the globalized economy is that international production, trade and investments are increasingly organized within the so-called global value chains (GVC) of cross-national activities, inputs, and dynamics. As GVC reshape policy thinking, they pose significant challenges to domestic industry competitiveness by positioning themselves towards global networks of production; the issue is the viability of inserting its own technology into products, processes, or routes, grasping a niche in the regional or global value chain.[19] On the regulatory front, the implications in the dynamics of interconnecting economies include a large set of regulation and policies to bring consistency to trade patterns, including: harmonization of regulatory frameworks; convergence of standards and certification requirements; and mutual recognition agreements.

Anchored in the availability of biomass, the operationalization of a global bioeconomy requires a relational approach.

To *developing* countries, the bioeconomy offers the potential to play their comparative advantages as raw material suppliers to the world-system economy – driven by biomass production, but relying on the widespread use of biotechnology, the digitalization of productive processes, and increased vertical integration of agriculture and industry. The bioeconomy could thus offer a comprehensive "development strategy", addressing hunger and alleviating poverty, as well as creating jobs and growth, while being in tune with the most important sustainability concerns in terms of renewable energy and climate change. For *developing countries*, a key issue is how their role as biomass suppliers to a global bioeconomy can be coherently integrated with science and innovation, domestic industrial policy, and development objectives. The alignment with this global process – through intensification and large scale industrialization of the agricultural sector – could foster innovation and opportunities to move these countries "upwards in the value chain", producing higher value products to the world market.

For most *developed* countries, strategies include how they will secure biomass sourcing globally and guarantee its predictable supply,[20] as well as ways through which biomass production elsewhere will be integrated into its knowledge-based technologies and patents.

Biotechnology is a major contributor to a KBBE, defined by the European Commission as the process of

18 Pyka, A. (2015) Transformations of Economic Systems: The Bioeconomy Case.
19 https://www.ecb.europa.eu/home/pdf/research/compnet/Policy_Brief_no_6.pdf
20 Comparative study on developed country strategy with (Finland) and without (The Netherlands) own sourcing of biomass.

"transforming life science knowledge into new, sustainable, eco-efficient and competitive products". When embedded on key routes and processes, biotechnology is seen as a driver of the "cascade effect" (food/feed – materials/chemicals – energy), integrating multiple products through the "biorefinery approach" in a similar way to the petrochemical industry: driving opportunities through new products such as second generation fuels, synthetic plant-based chemicals, industrial fluids, probiotics, functional foods, bioplastics for food and beverage packaging, biotrade, and biopharmaceuticals.

With applications across all biological resources, including the entire set of life forms – from genes, viruses, bacteria, yeasts, and micro-organisms in general, to algae, plants and animals – biotechnology is the catalyst and main engine to enable a bioeconomy.[21]

However, a major constraint developing countries must contend with regarding policy and strategies is the level of integration that *already exists* in key sectors related to the advancing of the bioeconomy, such as agroindustry and life sciences, and the pharmaceutical sector. Recent examples concerning the further concentration of major players in the agro-biotech sector reflect the scale of such a catalytic role.

Bayer's announced acquisition of *Monsanto*, creating a global leader in agriculture *"realizes the companies' shared vision of integrated agricultural offerings, delivering enhanced solutions for growers and creates a leading innovation engine for the next generation of farming. The combination brings together two different, but highly complementary businesses. The combined business will benefit from Monsanto's leadership in Seeds & Traits and Climate Corporation platform along with Bayer's broad Crop Protection product line across a comprehensive range of indications and crops in all key geographies."*[22] This is a package that also includes an *"optimized product suite based on analytical agronomic insight and supported by Digital Farming applications"*. The ongoing acquisition of *Syngenta* by *ChinaChem (China National Chemical Corporation)* is another similar merger.[23]

As the integration of value chains advances through *flex crops* – key drivers of global agri-food system change, these commodity crops enable multiple use and allocation among food and/or non-food uses – these recent mega-mergers within the corporate world are emblematic of the dynamics of scale of the biopower embodied by the materialization of a bioeconomy.

Low carbon bioeconomy?

Promoted as an opportunity to redesign the current fossil fuel-based economic model, a bioeoconomy envisions a scenario whereby an increasingly circular, low carbon economy can be forged through fostering more "efficient" circuits of industrial production and consumption, aimed at reducing or eliminating residues (organic, liquid, and steam flows), waste, and emissions.

Climate-resilient development[24] crosses over into a low carbon bio-economy[25] and vice versa. Climate-based reasoning and environmental accounting grounded in carbon footprint and life cycle analysis increasingly anchors defining elements of bioeconomy strategies, such as "efficiency" and "sustainability" criteria, and how, increasingly, one is equated with the other. Biofuel obligations in Germany since 2015 are to be met based on a greenhouse gas (GHG) saving rather than on a volume basis. EU-approved Voluntary Sustainability Schemes, such as the *Roundtable on Sustainable Biomaterials (RSB)*, will play a key role in the new system as a GHG saving calculation serves to measure and validate the "efficiency" and superiority of the products when compared to its fossil-based counterparts, or less "efficient" bio-based concurrent.[26]

Indeed, an immediate antecedent to the current bioeconomy debate was the first generation of biofuels, which gained traction worldwide a decade ago as an efficient and cost-effective policy measure to reduce greenhouse gas (GHG) emissions in the energy and transport sectors, as recommended by the influential *The Economics of Climate Change* report.[27]

To fall under the "advanced biofuels" classification (second generation biofuels or cellulosic based fuels) in the US, a fuel has to deliver at least a 50 % GHG reduction compared to conventional fossil fuels;[28] in the EU, the minimum required emissions reduction is

21 Alfredo Aguilar, Laurent Bochereau, and Line Matthiessen 2009: Biotechnology as the engine for the Knowledge-Based Bio-Economy. In: Biotechnology and Genetic Engineering Reviews,Vol. 26, Iss. 1

22 Advancing Together. Bayer to Acquire Monsanto. Overview of the combination. https://www.advancingtogether.com/en/home/

23 https://www.syngenta-growth.com/en/home/

24 http://documents.worldbank.org/curated/en/401711468185370301/accelerating-climate-resilient-and-low-carbon-development

25 http://www.unfoldthefuture.eu/uploads/CEPI-2050-Roadmap-to-a-low-carbon-bio-economy.pdf

26 http://biofuelsnews.com/display_news/8673/new_ghg_requirements_for_voluntary_sustainability_schemes/

27 The report, also known as the *Stern Review*, was a landmark in fusioning the criteria to evaluate economic efficiency in GHG emissions. For instance, the political debate on the first generation of biofuels adopted the sustainability criteria that biofuels must achieve greenhouse gas savings of at least 35% in comparison to fossil fuels, as GHG savings were adopted as a criterion in the *Renewable Energy Directive* for the EU.

28 https://www.epa.gov/renewable-fuel-standard-program/program-overview-renewable-fuel-standard-program

60 %.[29] Second generation, cellulosic fuels are made out of non-edible biomass, such as agricultural residues (corn stalks, straw) and woody materials, and serve as fuels and as primary feedstocks for biorefineries to produce green chemicals, including plastics (packaging, bottles), and solvents.[30]

Although more clearly defined than climate policy, this interface relates to *how standards for key bioproducts are being shaped*, which will have implications for trade, certification, access to green markets, energy-performance-based procurements, etc.

In addition, the use of non-edible sources – so as not to compete with food production – and a required GHG performance minimum help legitimize, based on "technical" criteria, the overall acceptability of these fuels, leaving crucial land and biodiversity issues sidelined.[31] For instance, second generation fuels include biogas produced using enzymes, which break down the widest variety of cellulosic fibers and protein-rich materials, enabling faster fermentation and biogas production at a lower cost.[32] Biogas can also be integrated as feedstock to biorefineries and a better, "advanced" biogas quality is defined as methane/CO_2 ratio.[33] However, the technology for advanced biogas uses synthetic biology to create artificial enzymes to speed up the industrial processes – like fermentation – used to produce fuels, dye textiles, and process foods (sausages) and beverages (beer), etc. Redesigning living organisms to reprogram metabolic pathways so that they are in tune with the needs of the industry seems to be a core element in developing high value patents for the bioeconomy in the making. It is also a major concern regarding biosafety and the impacts on biodiversity.

Policy landscape or landscape governance?

Looking more generally at the bioeconomy policy making landscape, within the world's leading G7-economies, few have, to date, developed a national strategy that combines and articulates a more top-down approach involving research, industry, and policy – such as Germany. Many countries do not have a coherent strategy, but simply a bundle of bioeconomy-relevant policy. A key sectoral cluster of policies strictly related to structuring a bioeconomy include agricultural policy (such as the USA's *Farm Bill*, and Canada's *Growing Forward*) or biomass strategies (Japan), as well as action and programs that fall under the climate smart agriculture category.[34] In addition, renewable energy, as part of a broader and more integrative scope of climate policies, is also a fundamental platform to kickstart a bioeconomy at scale.

While in the policy field bioeconomy-related actions can appear more clustered around "research, innovation and industrial policies", approaches and strategies that *pave the way for a bioeconomy* include climate policy, renewable energy and transport, agriculture, biodiversity/biosecurity, and forests. Despite many countries' lack of focus or a specific strategy regarding the bioeconomy, as the road to the future is being paved, concerns are emerging regarding how the bioeconomy will be materialized on the ground, including the larger picture of how a broad regulatory framework that impacts directly on land, forests, and biodiversity will be formed. The ongoing dynamics of Latin America reveal that although not strictly referencing it, the path towards the bioeconomy is being integrated into national contexts.

Climate policy has served as an important structuring axis to pave the way for a bioeconomy. Within the current framework, sectoral "climate actions" are, by and large, creating enabling environments, introducing policies and measures for renewable energy, and creating mandatory targets for biomass and biofuels. In addition, by means of climate policy, laws and regulations are being created or modified to consistently address land use and the land use change sector. For example, forestry within a bioeconomy requires the *National Forest Inventories (NFI)* to provide precise information on forest and landscape resources at a large scale to answer the question of "how much" forest on a national scale, but also "where" forest and tree resources are on a local scale, combining field data with 3D remote sensing data, for example. This is addressed under the framework for REDD+, which lists the enhancement of carbon stocks and sustainable forest management among its activities, both of which are required to manage biomass stocks, reforestation/

29 E2, 2014; UNCTAD, 2014

30 The use of corn stalks turned into lignocellulosic biomass for biorefineries is highlighted as a plentiful and reliable feedstock for second generation fuels (cellulosic ethanol), with commercial-scale technology in operation, as well as for producing pellets and biogas generations. POET-DSM's Project LIBERTY and the *Abengoa Bioenergy Biomass of Kansas* facility opened in September 2014 in the US, becoming the nation's first commercial-scale cellulosic ethanol plant to use corn waste as a feedstock. The biorefinery uses a biological process to convert post-harvest corn stover into biofuel. http://www.energy.gov/eere/articles/cornstalks-arent-just-scarecrows-anymore

31 "*Energy-Smart Food at FAO: An Overview*": the FAO's work on energy in relation to specific components of the agri-food chain. The document can be downloaded at http://www.fao.org/docrep/015/an913e/an913e00.htm

32 http://www.dupont.com/products-and-services/industrial-biotechnology/advanced-biofuels/biogas-enzymes.html?id=biofuelsdigest-web

33 http://www.dupont.com/products-and services/industrialbiotechnology/advanced-biofuels.html

34 German Bioeconomy Council (2015) *Bioeconomy Policy Synopsis and Analysis of Strategies in the G7* http://bioeconomia.agripa.org/download-doc/64046

afforestation, and *Climate Smart Agriculture*, etc. Under climate reasoning, on accounting emissions, this is mostly done by bypassing biodiversity.

To put forward the bioeconomy vision, coordination at policy level is required to combine the technological advances with the cost and availability of biomass supply. Predictable flows of biomass will demand "cooperative approaches" between countries and medium and long-term strategies – considering the natural biological cycles, for instance, for a tree plantation – as well as a strong convergence of government and private sector, likely through increased Public-Private-Partnerships (PPPs).

A comprehensive governance structure will be required to guarantee continuous access to resources, harvesting, processing, and transport, etc., as well as a process that integrates at a considerable scale, interconnecting energy and industrial policy with elements such as land, biodiversity, water, agriculture, forestry, reforestation, forest restoration, jobs, and livelihoods.

In consonance with this framework, the concept of "landscape" has greatly evolved in recent years within the international policy arena into a unified, cohesive approach, able to encapsulate forests and agriculture, while meeting broader concerns with regard to climate and sustainable development goals.

A key element in this trend is the *Global Landscape Forum (GLF)*. Promoted as a dynamic platform for stakeholder engagement, it serves as a major lobbying ground for policy advice concerning climate negotiations. With support from the German government, it was recently upgraded to become a platform for global action and will hold its first meeting in 2017. Its permanent secretariat will be based in Bonn for the next four years.[35] As it enters a new phase in the implementation of action on the ground and tracking progress towards new climate and development goals, *"the GLF aspires through scientific input, capacity-building programs, online engagement, thematic symposiums and global events, to introduce one billion people by 2020 to the landscape approach - and connect them in embracing it"*.[36]

Considering the aims of the global biomass regime currently in the making, the envisioned scale of this endeavor requires massive integration of land to biomass production wired to the digital, "smart" infrastructure and to value chains.

In line with this demand, the concept of "landscape governance" is increasingly gaining visibility. Landscapes are understood as "resource systems" and landscape design and management cover food, bioenergy, and the bioeconomy.[37] Aiming to guarantee production, access and a steady supply of biomass for bioeconomy strategies and *governance* on the ground, at the landscape level, this global trend not only redefines and amplifies current "land" issues at large, but frames them as a core concern of the 21st century political agenda.

Over the last decade, policy and legal frameworks have been aligning towards a *land use regime* that paves the way for a bioeconomy. This includes the introduction of governance structures that are suitable to expand biomass production and harvesting. These range from economic-ecological zoning (qualifying for investments) to biofuel mandates, reforms in forest tenure and resource management (as with forest concessions and public-private partnerships), as well as certification schemes and market mechanisms to bring biodiversity and environmental services under valuation metrics, etc. Flagship climate measures include carbon and biomass (i. e. land) registries, actions to reduce and avoid deforestation under REDD+ including enhancement of carbon stocks and sustainable forest management, afforestation to create carbon sinks, and climate smart agriculture.

35 GLF was created in 2013 by merging two earlier global events – *Forest Day* and *Agriculture Day* – organized as part of annual climate negotiations. In 2016 it received support from the German Ministry for the Environment and the Ministry for Economic Cooperation. Other governments and organizations have expressed an interest in supporting the GLF's operations and regional forum events, outreach, and engagement with additional funds. Its mission will be to broaden reforestation and restoration commitments, and incubate innovative ideas for achieving the Sustainable Development Goals and solving the climate challenge. http://www.landscapes.org/

36 http://blog.cifor.org/46778/german-government-pledges-commitment-to-the-global-landscapes-forum?fnl=en

37 http://www.wur.nl/en/show/CDIcourse_landscape_governance_2017.htm

3 Latin America: breeding grounds for a bioeconomy?

Latin America holds an advantageous position with regard to its ability to develop a bioeconomy. Among the region's comparative advantages are the availability of land, water and biodiversity, the wide dissemination of biotechnology (today it accounts for almost half of all the area planted with GMOs globally), and the potential for competitiveness at a global level with its robust agroexport sector, as well as substantial experience in biofuel production (three of the world's top producers are in Latin America: Brazil, Argentina, and Colombia). The key factor that qualifies Latin America's overall environment for a bioeconomy concerns the political priority given to *agribusiness* in the region, where regulation on land use is forged in accordance with its interests and needs to expand.

The region holds one of the world's largest tropical biomass reserves, the Amazon, a continuous rainforest covering 6.9 million km^2 and comprising nine countries;[38] among these, Brazil, Colombia, Peru, Ecuador, and Venezuela are megadiverse – a term used to refer to the group of seventeen countries that hold 70 % of the earth's biological diversity.

Its abundant tropical arable land and water make the region particularly vulnerable to land grabbing.[39] Critical analysis has already called for the *current dynamics* to be addressed, resulting in *ongoing* "resource control grabbing", such as that promoted by international capital groups in order to gain control over vast tracts of land and associated resources, such as water, carbon, crops, or raw materials.[40] Nonetheless, studies on global availability of suitable land for bioenergy/biomass have estimated that across all developing countries, the largest percentage for any type of agricultural crop is located in Latin America, followed by sub-Saharan Africa. Optimistic scenarios refer to Latin America as having 500 million hectares under the *"most suitable land"* category for bioenergy expansion, while projections into 2050 foresee that around *"300 million hectares would still be available to be incorporated under agricultural production, without endangering native forests or protected areas in Latin America"*.[41]

Compared to other regions, a structural feature that highlights Latin America's potential as a viable candidate for a biomass-based bioeconomy is that it already has an advanced export-oriented tropical agriculture infrastructure that is linked to global markets and has many key features already installed, such as roads, railways, hydroways, mills, biofuel refineries, pipelines, and ports. In this context, the region contains the world's second- and third-largest countries with the largest areas under GMO cultivation: Brazil, with 44.2 million hectares, and Argentina, with 24.5 million hectares. This gives a combined total of 68.7 million hectares, representing *40 % of the area planted with GMOs globally,* which currently stands at around 180 million hectares (2015).[42] Other countries in the region that are growing GMOs include Paraguay, Uruguay, Chile, Bolivia, Colombia, Costa Rica, and Honduras.

Renewable energy is a major platform to kick-start a bioeconomy at a large scale and a key engine to incorporate technology, engage the private sector, and put the wider process towards a biofuture into motion. Through mandatory blends, targets, and access to climate finance, the increased share of biopower for fuels and electricity is seen as having a catalytic role in a global transition towards a low carbon bioeconomy.

Latin America is already a heavy producer, consumer, and exporter of biofuels. Brazil is the world's second-largest exporter of ethanol; in 2015 it produced 30 billion liters of sugarcane ethanol, and exported 7 % of its production, mostly to the US.[43] Argentina is becoming one of the key actors in the development of biodiesel markets, and a major world producer.[44] Made from (GMO) soybean oil, biodiesel production in 2015 was 2 billion liters, and the country exported 44 % of its production, mainly to the US and Peru.[45] Exports to the EU, impacted by anti-dumping duties since

38 Brazil, Bolivia, Peru, Colombia, Ecuador, Venezuela, Guyana, Suriname, and French Guyana.
39 https://www.fdcl.org/wp-content/uploads/2014/03/factsheet_landgrabbing_latinamerica_engl_web.pdf
40 Borras Jr., S. et al. 2012: Land Grabbing in Latin America and the Caribbean. In: The Journal of Peasant Studies, Vol. 39, no. 3-4, July - October 2012, pp. 845-872.
41 http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/GEA_Chapter20_bioenergy_lowres.pdf
42 (ISAA2015) http://www.isaaa.org/resources/publications/briefs/51/infographic/pdf/B51-Infographic_PlantingCountries.pdf
43 http://www.brasil.gov.br/economia-e-emprego/2016/05/etanol-atingiu-producao-recorde-de-30-bilhoes-de-litros-em-2015
44 Trigo, E.; Pahun, J .and Henry, G. (2014) *La Bioeconomia em América Latina: oportunidades de desarrollo e implicaciones de política e investigación*. FACES, año 20. N. 42-44. pp. 125-141
45 http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Buenos%20Aires_Argentina_7-21-2016.pdf

2013, should resume in 2017 after the WTO passed its judgment on the dispute, ruling in Argentina's favor.[46]

Policy shaping for the bioeconomy

A major promise of the bioeconomy is the opportunities it will bring to developing countries, offering different conditions from the ones faced by these countries during the beginning and consolidation of the world cycle of the oil economy.

Through highlighting the agroindustry's central role in this new global economic cycle, a biobased economic approach reframes the traditional "development" narrative, where "agriculture" is portrayed not as a backward sector to be abandoned in order to promote "industrial" development – conceived as progress and modernization – but as an entry point to a new cycle of growth in which the capacity for producing biomass at scale offers renewed conditions for countries to enter the global playing field.

Sharing a path dependency rooted in its common colonial history, Latin American countries have been integrated into the world economy mainly as suppliers of raw materials and commodities through rather "short" value chains, such as in agriculture, with no added value in processing technologies and services. In contrast, the current transition to a bioeconomy could allow these countries to be integrated into a global process by providing final products – or, at least, intermediate inputs – as countries that do not produce biomass must import it, and the transportation of unprocessed biomass is costly.

Given its vast potential as an environment well suited for large-scale biomass production and processing, shaping a joint policy perspective/partnership with Latin America is a strategic asset in larger, long-term supply plans.

The global biomass feedstock

The global biomass feedstock availability includes: *agricultural residues* (straws, maize stover, sugarcane bagasse, oil palm residue, seed husks), which are low density, bulky materials that can only be transported over limited distances and entail technical challenges associated with pelleting; *global energy crops* (eucalyptus, acacia, and other short rotation forestry species; miscanthus, switchgrass, energy cane, bamboo), all of which have a better yield potential in warmer, tropical climates; and *forestry and sawmill residues*

Partnering for the bioeconomy: EU-Latin America

In terms of the capabilities of this global transition, which is already underway, to tap into the bioeconomy's potential, early planning and policymaking made by countries is determinant to the pathways in which they will engage in the medium and long term. Time horizons vary, with plans outlined up to 2020, 2030, and even 2050 that are compatible with projections and the evolution of key markets, such as energy and land. Geopolitically, the European Union and the United States are leading the planning of the bioeconomy agenda for the coming decades and are strategically positioning themselves according to their special interests.

In this context, the EU has played an important role in the introduction, validation, and implementation of the bioeconomy concept in Latin America and the Caribbean (LAC), working steadily over the last decade to promote the concept in the region: Between 2007/2008 a series of meetings targeting experts from the EU and LAC were organized, bringing together researchers and policy makers to discuss the opportunities of the bioeconomy for the region, an exchange that contributed to the framing of a larger project within a bi-regional cooperation framework. [47]

Concerning the political aspect, the concept of the bioeconomy in the region has found increased recognition and support since the *VI European Union – Latin America and Caribbean Summit*, held in Madrid in 2010, where the development and implementation of the *EU-LAC Joint Initiative for Research and Innovation* was agreed, a commitment further pursued at Senior Officials Meetings held in 2011, 2012, and 2013.[48] This process resulted in the adoption of "bioeconomy" as one of the five *Joint Initiatives for Research & Innova-*

46 https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds473_e.htm

47 Jaramillo, E. de H. (2014) *Hacia um desarrollo de la bioeconomia em América latina y caribe en asociación com Europa*. Universidad Javeriana, Bogotá.

48 *"Towards a new stage in the bi-regional partnership: innovation and technology for sustainable development and social inclusion"*. Framing science and technology cooperation as being closely linked with higher education and actions to drive innovation, the initiative expected to "create conditions for strengthening the interface between research and innovation and to facilitate technology transfer and adaptation in formats accessible to micro and SMEs, including through knowledge and innovation centres network, participation in the *European Research Framework Programme*, progressive opening of national research programmes, interconnectivity between research infrastructures and promoting cooperation in capacity building human and institutional". http://www.europarl.europa.eu/intcoop/eurolat/key_documents/summits_eu_alc/vi_18_5_2010_madrid_en.pdf

tion guiding regional cooperation in Science and Technology. It was in this context that the project *Towards a Latin American and Caribbean Knowledge Based Bio-Economy in partnership with Europe* (ALCUE-KBBE),[49] was implemented from 2011 to 2012, aimed at formulating a bi-regional platform for the bioeconomy. With the goal of establishing an *"enabling policy and institutional environment"* and the development and consolidation of the KBBE in both the regions, the project had among its objectives "to insert the KBBE theme in ALC *policy agendas*, have its concepts mainstreamed in the region, as well to develop policy and institutional roadmaps".[50] While regional in scope, the project had a special focus on Argentina, Brazil, and Colombia, the countries with more advanced conditions to develop a bioeconomy approach, as well as being those with the most relevant bioethanol and biodiesel production.[51]

The ALCUE-KBBE platform entered into a new phase from 2013 to mid-2017: organized under an international cooperation network named ALCUE-NET, it aims at a broader scope of bi-regional cooperation to consolidate *policy dialogue* on science, technology, and innovation between CELAC and the EU, in tune with the International Science, Technology and Innovation (STI) dimension of the *Europe 2020* strategy.[52]

The ALCUE-NET included the *bioeconomy* among its pilot activities and established a dedicated working group, co-chaired by Argentina and France, focused on building bioeconomy roadmaps and agendas for research, development, and policy making; these include, for example, a *CELAC Bioeconomy Observatory*, closely linked to similar activities in the EU that connect policy, research, and markets.[53]

The ongoing work developed through the context of the ALCUE-NET project suggested four pathways in the field of bioeconomy for cooperation between EU and the LAC region: *biotechnology; eco-intensification; biodiversity; biorefinery; and products.*

Biotechnology; energetic crops: genetic improvement and efficient use of resources; artificial seeds for wood production; design and screening for multipurpose (flex) crops;

Eco intensification; development of bio-inputs and bio-products for integral crop protection and nutrition; agricultural diversity and crop productivity and stability, phytosanitary/integrated pest management

Biodiversity; screening for new bioactive metabolites and enzymes from terrestrial and marine micro-organisms for the food and cosmetic industry; health promoting compounds from plants; integrated open access LAC databases on native organisms and their functionalities;

Biorefinery and products; agricultural waste, agro-industrial, industrial forest (characterization and uses of bio-based waste and residues). Biorefinery of wet biomass – energy efficient processing. Lignocellulose and green biorefinery: production of new high value bio-based products. Biorefinery for sustainable food production (small scale biorefinery at current biomass processing sites). Production of biobased building blocks for polymers and bioactive compounds for the food, cosmetics, and pharmaceutical industry.

In addition to these pathways, *ecosystem services* and *value chain efficiency* were listed, but not dealt with at this phase.

In late 2015, ALCUE-NET, along with CEPAL, convened the first *Latin America and the Caribbean Bioeconomy Conference* to discuss the potential of bioeconomy as a reference framework for development and innovation policies, and strategies for the agriculture/agroindustry sector in the region, highlighting the potential of bioeconomy to promote competitive, inclusive, and sustainable development that contributes to the decarbonization of the economy.[54] During discussions at the conference, it was remarked that despite its potential, Latin America lacked dedicated policies and strategies for the bioeconomy; the closest such frameworks in the region were Brazil and Argentina's biotechnology and bioenergy strategies. Nonetheless, an ongoing process towards the "new productive re-

49 The program was financed by FP6 and FP7 of the EU. For more information on the program, see: http://www.bioeconomy-alcue.org/bioeconomy/index.php?lang=en

50 http://www.bioeconomyalcue.org/bioeconomy/index.php?option=com_k2&view=item&layout=item&id=1&Itemid=106&lang=en

51 *"The CSA project ALCUE-KBBE (Contract No. 264266) is co-financed by the European Commission's 7th Framework Program (2011-13). It is a consortium of 12 partners, aiming at establishing a LAC-UE platform as the basis for a political and institutional framework that encourages sustainable (non-carbon) and competitive development and strengthens the knowledge based bio-economy concept in the LAC region. The project is coordinated by CIRAD, France and hosted by CIAT, Colombia."*

52 ALCUE NET5 is a four-and-a-half-year project funded by the *7th Framework Program of the European Union.* The consortium is composed of 19 institutions, eight from the European Union and eleven from Latin American and Caribbean countries, representing stakeholders from government and research. *"The ALCUE NET objective is to establish a bi-regional European Union, Latin America and the Caribbean (EU-CELAC) platform, bringing together actors involved in R&I orientation, funding and implementation, as well as other relevant stakeholders from the public and private sector and the civil society."* http://alcuenet.eu/about-alcue-net.php

53 Website under construction at: http://www.celacbioeconomy.org/test/about.php
The cooperation action includes awareness-raising initiatives aimed at overcoming the lack of a bioeconomy *policy perspective* and the "lack of institutional recognition of the bioeconomy as a model for sustainable and inclusive sustainable development" among politicians and policymakers. It also includes overcoming the lack of scientific capacities and technical resources in the scientific and academic community, providing evidence for the private sector concerning market opportunities for profitable business development, and engaging with NGO and consumers who play a key role in the acceptance of bio-economy products.

54 http://www.cepal.org/sites/default/files/events/files/agendabio_eng.pdf

ality" of a bioeconomy includes many solid platforms in the region upon which wider actions can be built.[55] Considering the broader policy landscape, despite the lack of a unifying, integrative framework, many bioeconomy-related policies are paving the way for the future of the bioeoconomy in the region.

Enabling environments

Argentina: biotechnology and smart territories

According to the *Ministry of Science, Technology and Productive Innovation (MINCyT) "the bioeconomy is strategic for Argentina to complete its industrialization process and insert itself into the knowledge based economy"*; while Argentina does not yet have a dedicated bioeconomy strategy, the bioeconomy already accounts for 15 % of Argentina's GDP, which was achieved rather spontaneously, without articulated policies, and relying heavily on advances through *biotechnology.*[56]

Argentina has taken consistent steps towards strengthening its role as a biotechnology player: In addition to the country's capacity as a well-established biomass producer for the global market and the world's third-largest producer of GMOs, it also lists a steady supply of locally developed varieties and events, including drought resistant soy and sugarcane and virus-resistant potato.[57] Argentina currently has more than 180 biotechnology enterprises (seeds, biological products, pharmaceutical, industrial inputs), a growing development of first generation biorefineries based on sugarcane and corn (ethanol) and soy (biodiesel), and is taking its first steps towards green chemistry.[58]

Argentina was a pioneer in the region in terms of adopting biotechnology at scale, with the first commercial GMOs authorized in 1996;[59] now it aims to play a leading role at a regional level with endogenous biotechnology development, as well as South-South cooperation, for example with South Africa as a gateway to sub-Saharan Africa's agro-biotech markets.[60] Another important long-term initiative is the bilateral *Brazilian-Argentinian Center of Biotechnology* (CBAB-CABBIO), created three decades ago in 1987: It is a key example of a regional cooperation instrument into which Uruguay has recently been included.[61] Together with France, Argentina co-chairs the CELAC-EU working group on Bioeconomy.

The *Argentine Chamber of Biotechnology* is the country's major industry and science body, comprising more than twenty companies, some of which have become transnational.[62] The Chamber works synergically with the *MINCyT*, as well as with the Ministry of Industry, the Ministry of Health, and the Ministry of Foreign Affairs. Another important actor working closely with the government in shaping policies is the *Argentinian Forum on Biotechnology* (*Foro Argentino de Biotecnologia*), composed of the private sector, institutions and researchers, created in 1986, and serving as a reference at national and international level.[63]

Biotechnology assumed the position of a priority sector in 2012 with the launch of *Plan Argentina Innovadora 2020* (*Innovative Argentina 2020 Plan*).[64] The document specifies the main guidelines for innovation, technology, and scientific development policy for the period 2012-2015, elaborated by the *MINCyT* through consultation with the private sector, NGOs, the scientific community, and public officials from other ministries. Created in 2007, the *MINCyT* has been the main institutional body for guiding and creating systemic drive to deliver productive innovation for the creation of public policies in science, technology, and innovation. The plan defines three strategic technologies to be

55 Another key regional event in late 2015 was the *4th Latin American Congress on Biorefineries* (held jointly with the *3rd Iberoamerican Congress on Biorefineries* (CIAB) and the *2nd International Symposium on Lignocellulosic Materials* in Concepción, Chile. The Congress on Biorefineries was organized by the *Technological Development Unit*, UDT, the *Biotechnology Center*, CB-C, both from the *Universidad de Concepción*, Chile, the *Iberoamerican Network on Pulp and Paper Teaching and Research*, RIADICYP, the *Iberoamerican Society for the Development of Biorefineries*, SIADEB; *CYTED PROVALOR* network, the *Scientific and Technological Center on Bioresources*, BIOREN of the *Universidad de la Frontera*, and the *VTT* company, *Technical Research Centre of Finland Ltd.* http://www.biorrefinerias.cl/latin-american-congress-on-biorefineries-2015/?lang=en

56 http://www.agro.uba.ar/delsuralmundoen2030/?page_id=4407

57 CONICET/UNL/Bioceres drought resistance soy and CONICET/Tecnoplant virus resistant potato.

58 Bisang, Las empresas de biotecnología en Argentina, MinCyT, 2014

59 Along with the rapid development of a large soy oil industry in the 1990s, the country approved the production and sale of GMO soy in 1996 and by 1999 75% of its soy crop already contained GMO. Early adoption and widespread dissemination of GMOs in Argentina had a strong impact regarding regional soy expansion, having directly influenced the introduction of GMOs throughout Mercosur, such as in Brazil, where the illegal planting of smuggled seeds brought in from Argentina was key to the legalization of transgenics in the country, as well as in Paraguay and Uruguay. Hochstetler, K. (2006) *The multilevel governance of GM food in Mercosur.* In: Falkner, R. (Ed). The International Politics of Genetically Modified Food. Palgrave Macmillan, New York

60 See, for example, *Green Agro*, an Argentinian agribusiness company active in Kenya. http://www.agro.uba.ar/delsuralmundoen2030/wp-content/uploads/2016/04/Una-empresa-argentina-en-%C3%81frica-El-caso-de-Green-Agro-Ltd-Juan-Rusinek.pdf

61 http://www.mct.gov.br/upd_blob/0231/231560.pdf

62 http://cabiotec.com.ar/en/

63 http://www.foarbi.org.ar/institucional/

64 http://www.mincyt.gob.ar/adjuntos/archivos/000/022/0000022576.pdf

developed in the period leading up to 2020 – biotechnology, nanotechnology, and information and communication technologies (ICTs) – and sets 34 productive sectors as a priority with 16 designated as important components of a bioeconomy. They include: technological platforms, seeds, food processing, biorefineries and green chemistry, animal production, forestry/cellulose, second-generation biofuels, ocean resources, GHG mitigation, economic valorization of residues, restoration of degraded environments, ecosystem services, and energy crops.

In 2012 the *PROBIOMASA* (*Probiomass*) program was launched through an agreement between the Ministries of Agriculture, Energy and Federal Planning, and the FAO.[65] As of 2015, its goal was to triple the use of biomass in the Argentinian national energy balance towards making it account for 10 % of energy provision, utilizing agriculture residues. In 2012 the energy sector accounted for 43 % of GHG emissions in the country, and oil and gas accounted for more than 85 % of the total energy sources. [66]

The official public installation of the bioeconomy concept was presented as part of a broader national strategy that started in 2013 with annual national symposiums hosted by *MINCyT* to promote and debate the idea at a national level.

The *Bioeconomía Argentina* is a national dialogue and policy shaping process that was held nationally in 2013, 2014, and in 2015; in 2016 the national event was complemented by regional events, co-hosted by provincial governments, that aimed to identify elements for public policy related to the promotion of the bioeconomy concept at a national and local level as a way to shape future agendas on this issue.[67]

An element highlighted by Argentina as key to its competitiveness in a bioeconomy was its advances into the "smart agriculture" platform, placing its trust in vast "smart" territorial coverage (*territorios inteligentes*) and referring to the extension of crops under no-till technology (*siembra directa*). For the 2014/2015 harvest year, an average of 90 % of all the main crops in the country were produced using this technology (92 % soy; 88 % wheat; 94 % corn/maize; 80 % sunflower; 78 % sorghum), covering approximately 31 million hectares.[68] Combined with the biotechnology package, industrial no-till technology is part of the "precision agriculture", which is increasingly coupling mechanization with digital technology, remote sensing, and Big Data.

Released in late 2016, *Argentine Biotechnology to 2030 – strategic key to a techno-productive development model* is a concept paper resulting from a consultancy study for the biotechnology sector, financed by the *World Bank*, and developed for the *MINCyT* and the consortium *UBATEC S.A* as well as the *Argentine Chamber of Biotechnology* between 2015/2016.[69] The study focused on the development of biotechnology in Argentina, including a diagnostic of the sector, intellectual property, and value chain analysis. The paper builds a "future hypothesis" with distinct scenarios for 2030:

1. stuck in commodities;
2. socio-productive modernization via imported technological convergence;
3. towards a biological society.

The value of these prospective scenarios is mostly on its capacity to generate ideas, orient strategies and actions, and inform the decision-making process by applying the power of the bioeconomy narrative as a "futuring" one, recalling common images. According to the biological society scenario, in the future, "circularity, cascade process, and zero residue, are transformed into central and generalized principles to all sectors of the economy, penetrating the agents behaviors and modifying society and culture". This challenge is contextualized within the current global economic changes in a technological and social landscape which includes: the advance of the internet of things, 3D printing, increasing automatization (robots) for the military, industry, and commercial use, new biotechnology frontiers could offer a strategic window of opportunity in the fields of omics analysis (English language neologism referring to a field of study in biology ending in *-omics*, such as genomics, proteomics, or metabolomics), bioinformatics, systems biology, synthetic biology, artificial cells, and gene editing.

Upon succeeding the *Kirchner* governments (2007–2015), who had imposed price controls and high taxes on the agricultural industry, *Macri* U-turned and became pro-agribusiness, eliminating export taxes (*retenciones*) that had been imposed on wheat, corn, and sorghum, and reducing soy export tax from 35 % to 30 %. Since its inception, the *Macri* administration has promoted pro-market measures which have so far only generated positive impacts on the agricultural sector, upon which the economic recovery is now heavily dependent.[70]

65 http://www.probiomasa.gob.ar/
66 http://www.energypress.com.ar/81320-el-programa-probiomasa-permitira-usar-el-potencial-de-la-biomasa-como-fuente-de-energia
67 http://www.bioeconomia.mincyt.gob.ar
68 Bolsa de Cereales de Buenos Aires/Aapresid
http://www.aapresid.org.ar/wp-content/uploads/2016/10/Estimaci%C3%B3n-de-superficien-en-SD-1.pdf
69 Loan IBRD 7599/ AR
70 http://brujulacomunicacion.com/index.php/cooperativa/periodico-sursuelo/item/803-la-argentina-de-los-agronegocios

It is interesting to note that while social movements oppose and criticize agribusiness (*agronegocios*) as part of the extractivist model and an example of bad development (*maldesarrollo*)[71], the official discourse promotes the advancement of biotechnology *via* agribusiness as a leveraging strategy to complete the industrialization process towards a post-extractivist, knowledge-based economy.

Colombia: bioprospecting and biotrade for peace

Colombia does not have a dedicated bioeconomy strategy. However, within a broader development strategy, biotechnology, and specifically bioprospection for the commercial use of its mega-biodiverse genetic resources, are framed as pillars of Colombian competitiveness. While climate and development policies increasingly incorporate strategies for biomass and biofuel production, a major productive transformation for the rural areas in the country is envisioned as part of the ongoing peace process.

In the 2000–2014 period the Colombian economy has shifted from basic manufacturing to commodity exports and minerals (primarily oil and coal). The 2011 General Royalties System introduced a 10 % diversion of royalties from mineral income to science and technology development. In conjunction with its peace deal, Colombia is focusing on modernizing the economy, shifting to an innovation, knowledge-based socio-economic development model.

Colombia's National Development Plan is the main basis for the governmental policies of the country's presidency. *Juan Manuel Santos'* 2010–2014 "prosperity for all" plan (*Plan Nacional de Desarrollo 2010–2014 "Prosperidad para Todos"*) placed a heavy emphasis on strengthening Colombia's science, technology, and innovation capacity.

A major part of this plan aimed at developing and building the country's biotechnology sector. Although there is currently no sectoral representation of the biotechnology sector in the country, a national biotechnology institute and specific national program were introduced as early as the 1980s and 1990s respectively, and a national framework/strategic plan has been in place since the late 1990s. Since 2005, Colombia has authorized several GMOs for human and animal consumption including: corn/maize, cotton, wheat, beetroot, rice, and soy. The country is the world's second-largest exporter of ornamental flowers and produces GMO roses and carnations. Colombia is currently researching ways to develop GMO sugar-cane, coffee, tobacco, and potato.[72]

The 2010–2014 National Development Plan included the *Policy for the commercial development of biotechnology from the sustainable use of biodiversity* (*CONPES 3697*), released by the *National Council for Economic and Social Policy* and *National Department of Planning*. It was introduced in 2011 as the landmark framework for the commercialization and development of biotechnologies.[73] Known as the *Biotechnology Law*, *CONPES 3697* sought to improve the investment environment in the area of biotechnology, strengthening support for biotech activities across public and private sectors to attract resources for the development of commercial enterprises and products based on the sustainable use of biodiversity (specifically of biological, genetic resources and their derivatives). Strategic resources here include unique ecosystems for microbial collection, possible new species and enzymes, new metabolic routes, and metagenomic sequences.[74] A key feature of this framework was to enable greater access to genetic and biological resources, adjusting the regulation on the production and marketing of biological drugs, and establishing venture capital funds.

With the intention of making bioprospecting part of a broader development strategy, a major component of the *CONPES 3697* considers the potential creation of an *Empresa Nacional de Bioprospección* (*National Bioprospecting Company*). Indeed, while the establishment of such an entity is undergoing a feasibility study, *bioprospecting* has grown into a separate agenda in the national context as well as a potential development mechanism through cooperation – one which promotes the advancement of endogenous science and technology.[75]

Responsible for only 0.37 % of global greenhouse gas (GHG) emissions, in 2012 the country outlined the *Colombian Low Carbon Development Strategy* (ECDBC) including sectoral plans and scenarios up to 2040.[76] With a strategy of setting short, medium and

71 Svampa, M. and E. Viale (2014), Maldesarrollo Buenos Aires: Ediciones Katz

72 *Centro de Investigación de Caña de Azúcar de Colombia* (CENICAÑA); *Centro Nacional de Investigación de Café* (on coffee), tabaco enano y Beauveria Bassiana; *Corporación para Investigaciones Biológicas* (CIB) (on field trials for Bt potato). *http://worldfoodscience.com/article/proceso-de-adopci%C3%B3n-de-ogm-en-colombia-sistema-nacional-de-bioseguridad-abstract-english*

73 https://www.cbd.int/doc/measures/abs/post-protocol/msr-abs-co-es.pdf

74 The framework boosted support for various government agencies (including the Ministries of Commerce and Science, Technology and Innovation), scientific capacity building and applied research in universities and research institutions, as well as support for industry-academic collaboration, technology transfer, and biotech start-ups.

75 http://www.revistas.unal.edu.co/index.php/actabiol/article/view/33444/40205

76 https://colaboracion.dnp.gov.co/CDT/PND/PND%2020142018%20Tomo%201%20internet.pdf

long-term goals to decarbonize its economy and disconnecting a rise in GHG emissions from national economic growth, the country seeks to attract finance and technology transfer, preparing its economy to transition to a low-carbon global economy, achieving development goals in a carbon-efficient way, and "avoiding future market barriers".[77] Mitigation actions include agricultural intensification and increased biofuel and biomass production. Since 2005, the biofuels sector in Colombia has grown as the government has targeted biofuels as a strategic sector; the two largest segments within the sector are sugarcane-based ethanol and palm oil-based biodiesel. Colombia is one of the leading sugarcane producers globally as well as being the top producer of palm oil in Latin America and the fifth largest in the world.

Additional biotechnology policy frameworks include the 2014–2018 *Programa Nacional de Biocomercio Sostenible – PNBS (2014–2018 National Program of Sustainable Bio-trade)*[78]. The plan aims to develop Colombia's position as a major competitor in the global trade of biotechnological products and develop the country's biotechnology capacity, including targets of increasing innovation in the private sector, the development of commercial biotechnology products, increased levels of patenting, and significantly increasing biotechnology's contribution to national GDP. The program frames bioprospecting as a strategy for conservation and sustainable economic development, and presents a framework based on an ecosystem approach that has set a strategy for the integrated management of land, water extensions and living resources, and for the development of "sustainable value chains from a shared management of natural resources".[79]

The economic opportunities of green growth as part of a development strategy for the country was included in the latest *Plan Nacional de Desarrollo 2014–2018 "Todos por un Nuevo Pais"* (*National Development Plan 2014–2018 "All for a New Country"*).[80] The new political narrative emphasizes the role that the pacified rural areas will play in Colombia's post-conflict era, reinforcing bioprospecting and biotrade across a transformational paradigm.[81] The plan focuses on three main pillars: peace, equity, and education. These pillars are to be achieved with what are termed "crosscutting strategies", bringing a strategic vision and outlining Colombia's future.[82] Within the scope of the peace process, the plan has set *"rural transformation and green growth"* as one of its five priority areas. The plan to modernize rural areas includes cartography, land registries, land titling, and roads (road access). This strategy aims at promoting green growth, including valuing natural capital, restoring landscapes, introducing economic instruments for the valorization of biodiversity, natural capital accounting, and unifying guidelines for land planning and ecological economic zoning.

In 2015 the government launched *Misión Rural 2015* (*Rural Mission*), a strategic plan to be implemented from 201–-2035 that aims to transform the rural areas of Colombia over the next 20 years.[83] Serving as the main stage for an armed conflict that has lasted decades, there is a vision for rural areas to be "radically transformed" as a result of the peace process, opening opportunities up for accessing territories and genetic resources that until now have been off limits. According to the National Agricultural Census carried out in 2014, Colombia has an estimated 44.5 million hectares with agricultural potential.[84] The *Misión Rural* program is based on structural reforms aimed at productive inclusion, fostering industrialization of agriculture and integration into supply chains and international markets, setting forest inventories, territorial zoning, land use planning, and promoting climate smart agriculture and biomass production. Lauded as a chance for the country to "pay its debt" with a marginalized sector, rural areas are highlighted as an essential element to peace and for generating the income necessary to finance policies and programs needed in the peace transition.

Brazil: the emerging biopower

Within the region, Brazil offers the most advanced conditions for a developing bioeconomy. The country is

77 The strategy is institutionalized in *CONPES 3700* under *"Climate Change"*.
78 Released in 2012; revised version in 2014 http://www.minambiente.gov.co/images/NegociosVerdesysostenible/pdf/biocomercio_/PROGRAMA_NACIONAL_DE_BIOCOMERCIO_SOSTENIBLE.pdf
79 The plan sets out its goal to harmonize the legal, regulatory, institutional, and political frameworks across Colombia, prioritize the potential of different value chains in order to identify and address the technological needs of each value chain, achieve international accreditation for locally produced biotechnological products, and encourage private sector investments in R&D.
80 https://colaboracion.dnp.gov.co/cdt/prensa/bases%20plan%20nacional%20de%20desarrollo%202014-2018.pdf
81 http://unctad.org/meetings/en/Presentation/ditc-ted-16082016-colombia-4-colombia.pdf
82 Cutting across all segments of socio-economic development from general competitiveness and improvements to infrastructure (both physical and technological), social mobility, security and reforms to the justice and legal system, and an emphasis on good governance.
83 The 2014 census was the third carried out in the country, almost half a century after previous ones (1960 and 1970). https://colaboracion.dnp.gov.co/CDT/Agriculturapecuarioforestal%20y%20pesca/El%20CAMPO%20COLOMBIANO%20UN%20CAMINIO%20HACIA%20EL%20BIENESTAR%20Y%20LA%20PAZ%20MTC.pdf
84 https://www.dane.gov.co/index.php/estadisticas-por-tema/agropecuario/censo-nacional-agropecuario-2014

one of the world's largest biomass producers, has over four decades of experience with biofuels, and could potentially be a major player in the development of value added bio-products, such as second generation ethanol and biopolymers.

Despite these relatively substantive initial advantages, the country lacks a national bioeconomy strategy with goals and targets to be achieved within a broader, bio-based economic policy framework, limiting the further integration of the existing initiatives.

The fifth-largest country in the world, with a tropical, continental territory, Brazil is a biodiversity and agricultural powerhouse. The country currently has 71 million hectares under cultivation (2014/2015), an area two times the size of Germany (35.7 million hectares).[85] Brazil is the second-biggest grower of biotech crops after the US, and accounts for one fourth of all biotech crops cultivated globally.

One of its key competitive edges lies in the scale at which Brazil has consistently incorporated biomass production and used it at very significant levels throughout its economic and energetic model: biomass-based sources accounted for *30 % of the total national energy offering* in 2016, including sugarcane ethanol and sugarcane bagasse for electricity generation, bio-charcoal and wood/cellulose for pellets, biodiesel, black liquor, and biogas.[86] In addition, the domestic Brazilian sugar-cane ethanol industry is one of the biggest in the world and provides flagship initiatives and technological innovation in key sectors, such as in biofuels and green chemistry. *Cosan*, listed among Brazil's top ten exporting companies, is the world's first vertically integrated bioethanol firm; in a joint venture with *Shell*, it has formed *Raízen*, a pioneer in second generation cellulosic ethanol.[87] *Braskem*, another Brazilian export giant, is a global landmark in bio-based plastics and green chemistry.[88]

While there is a pressing need for a dedicated national bioeconomy strategy and a coherent regulatory framework, given the broader context and the escalating political instability since the impeachment of President *Dilma Rousseff*, the future of any policy landscape is unknowable at this point. However, amidst one of the worst economic recessions the country has seen in several decades and the collapse of important segments of the Brazilian economy, such as engineering services and heavy construction, the agribusiness sector has managed to produce the largest grain harvest in the country's history: 219 million tons for 2017.[89] Indeed, one of the first measures carried out by *Rousseff's* successor, *Michel Temer*, was to nominate *Blairo Maggi*, once known as the "soy king", as its Minister of Agriculture. Agribusiness corporations are among the main private financiers of electoral campaigns and buyers of advertising space in the media.[90]

The initial outline for structuring the policy framework for a bioeconomy in Brazil started in earnest a decade ago. Released in 2007, the *National Biotechnology Development Policy* (*Política de Desenvolvimento de Biotecnologia, PDB 2007*) and the *National Committee on Biotechnology*, representing close to a dozen relevant government agencies and ministries (including the Ministry of Trade's Innovation Secretariat, the Ministries of Agriculture, Health and Science, Technology & Innovation), was the first materialization of a political will to enter the country onto the global biotechnology market: The policy goal was to generate the potential so that by 2017–2022 Brazil would be

"Agro is Tech, Agro is Pop, Agro is everything" (Agro é Tech, Agro é Pop, Agro é tudo).

Under this slogan, an aggressive marketing campaign was launched in Brazil in mid-2016. Scheduled to last until 2018, the communication strategy aims to reframe the public perception of the country's agribusiness sector. It portrays how agribusiness production is a part of each and every aspect of the daily lives of urban citizens, highlighting its role in the country's economy, and the jobs it generates. A key message is to rebrand the "agro" not as representing backwardness, but "industry-richness", embedded with high-technology and innovation, and serving as an anchor for economic stability. The campaign was conceptualized and sponsored by the *Globo* organization, the largest mass media conglomerate in the country (and the largest in Latin America). Since its inception, it has been criticized and opposed by civil society and social movements for promoting a sector responsible for widespread use of agrotoxics, GMOs, violations of labor and environmental legislation, and a causer of land conflicts. The *Globo* conglomerate has played an active role in the 2016 impeachment process against President *Dilma Rousseff*.

85 http://www.agricultura.gov.br/arq_editor/PROJECOES_DO_AGRONEGOCIO_2025_WEB.pdf
86 https://ben.epe.gov.br/ (Brazilian Energy Balance, 2016–using 2015 data)
87 http://www.raizen.com.br/en/energy-future/renewable-energy-technology/second-generation-ethanol
88 Workman, Daniel (2016) Brazil's top 10 exports. July 23. http://www.worldstopexports.com/brazils-top-10-exports/
89 http://www.conab.gov.br/imprensa-noticia.php?id=43011
90 http://www.mst.org.br/2016/10/19/o-agro-e-cidio.html

among the five largest centers in the world for research, service generation, and biotechnology products.[91]

Another important framework was the *National Energy Plan 2030 (PNE 2030)*, conducted by the *Energy Research Company (EPE)* in close cooperation with the *Ministry of Mines and Energy (MME)*. In 2007 it released the first study of integrated energy resource planning carried out within the remit of the Brazilian Government.[92] It was the first long-term energy planning study-policy guideline covering not only the issue of electric energy but also of other energy sources – notably oil, natural gas, and biomass – comprising the first broad and detailed overview of systematic biomass applications for energy generation related processes, including production issues, technology, and market projections.[93] A *National Energy Plan 2050 (PNE 2050)* set for release in 2017 is currently being finalized, and is expected to increase the projections for steady biomass demand.

Since the beginning of the *Lula* era in 2003, Brazil has adopted a neo-developmentist strategy to strengthen its national industry. This was reflected in successive industrial policy documents from the period:

- The *Industrial, Technological and Foreign Trade Policy (PITCE)* of 2004;
- The *Productive Development Policy (PDP)* of 2008; and
- The *Greater Brazil Plan (Plano Brasil Maior, PBM)* launched in 2011 under the *Dilma Rousseff* presidency and focusing on innovation. Criticized for targeting more fiscal incentives and subsidized credit than effective measures to promote technological development, one quarter of its measures targeted the agro-industry.

From 2011 to 2013 the industrial sector mobilized intensively towards enhancing a bioeconomy framework to lobby the government and to kick-start a public dialogue. Biotechnology and biodiversity were listed as priority issues for innovation to improve the competitiveness of Brazilian industry. In this context, the *National Confederation of Industry (CNI)* under its Corporate *Mobilization for Innovation (MEI)* group launched its agenda for stimulating innovation in Brazil in 2011.

A key study in this context was organized by the *Brazilian Association of Biotechnology (BRBIOTEC Brasil)* and carried out by the *Brazilian Center Analysis and Planning Analysis (Cebrap)*. It was the first comprehensive study of sectoral biotechnology in Brazil, and produced a "biotechnology map", presenting the growth in the number of new companies between 2001 and 2011, a regional perspective of the geographical distribution of companies and scientific production – an effort to write new public policies that are more in tune with the realities of business and science.[94]

In 2012 the *MEI initiative*, in partnership with the *Harvard Business Review Brazil (HBR Brazil)*, held the *"Bioeconomy Forum: Developing an Agenda for Brazil"*. This event was the first multisector and international debate on the subject in Brazil and was a response to Brazilian industry's desire to make economic, social, and environmental progress in developing the country's bioeconomy. The result was the document *"Bioeconomy: An Agenda for Brazil"*,[95] launched in 2013 and bringing a comprehensive vision and policy proposals in line with the *2013 –2022 Strategic Road Map for the Industry*.[96]

The Bioeconomy Agenda identified key hurdles, such as a lack of coordination among the government agents involved with the various stages of the bioeconomy chain, the need for an alignment of initiatives, and coordination between the various government agents involved in the bioeconomy.[97] Among the private sector proposals were key concerns about the juridical insecurity of the current regulatory framework and the need to modernize the law concerning access to genetic resources, biosafety, intellectual property, and innovation.

Indeed, the new framework for accessing genetic resources, the Law on Research relating to Biodiversity and Biotechnology, was issued in 2015 *(Lei 13.123/2015)*, and revoked the legal framework that had been in place since 2001 *(Provisional Measure 2186-16)*. The law introduced features to simplify the registration procedure, with the aim of facilitating the process for researchers as well as the commercialization of new products and technologies. To this end, requests to access genetic resources are to be managed

91 http://www2.camara.leg.br/legin/fed/decret/2007/decreto-6041-8-fevereiro-2007-550858-norma-pe.html
Among its objectives were: establishing an adequate environment for the development of innovative biotechnological products and processes; stimulating the greater efficiency of the national productive structure; increasing the innovation capacity of Brazilian companies; absorbing technologies, generating business, and expanding exports. The *PDB* prioritized four areas of biotechnology development (human, agricultural, industrial, and environmental health) and for each of them the elaboration of a specific program with strategic targets within priority and border areas.

92 http://www.epe.gov.br/PNE/Forms/Empreendimento.aspx

93 The previous references available in the scope of government entities are the studies of *Petrobras* (in the area of oil and gas), and *Eletrobrás* as coordinator of the former *Coordinating Group for Planning of Electric Systems* (in the area of electricity).

94 http://www.cebrap.org.br/v1/upload/pdf/Brazil_Biotec_Map_2011.pdf

95 http://arquivos.portaldaindustria.com.br/app/conteudo_24/2013/10/18/411/20131018135824537392u.pdf

96 http://www.abit.org.br/adm/Arquivo/Servico/114357.pdf

97 https://energy.gov/eere/bioenergy/downloads/federal-activities-report-bioeconomy

by an electronic registry, yet to be created. An implementing *Decree (8.772/2016)*, among other things, introduced a tax corresponding to 1 % of the final price of products created using the country's biologic resources. Dubbed a "biopiracy law", it has been opposed by civil society as it would only benefit business and industry, allowing, for example, access to community seed banks without the need for prior permission or benefit sharing.

Despite the lack of a dedicated strategy, a "vision on Bioeconomy" started to emerge out of key sectoral studies:

Chemical Industry Diversification Study, contracted by *BNDES* and *Bain & Company and Gas Energy* (2015). While the study does not mention bioeconomics, a specific report (2014) on Renewable Chemistry identified it as one of the promising segments and an opportunity to diversify the Brazilian chemical industry[98], as Brazil is highly dependent on imported chemicals. Biomass-based industry dynamics are presented and Brazilian opportunities are identified and detailed at the product level.

Study on the perspectives of ethanol 2G in Brazil, carried out by the *BNDES Biofuels Department* and by the *CTBE*.[99] With the objective of promoting the implementation of public policy mechanisms that accelerate investments in new E2G plants, the study presents estimates of the potential for efficiency improvement and cost reduction of E2G in different technological scenarios. The E2G is presented as capable of transforming the current techno-economic paradigm of the sugarcane industry, rescuing the sector's competitiveness.

Renewable Chemical Industry Technological Agenda carried out by *ABDI* and *CGEE* within the *Greater Brazil Plan*, the broader Federal Industrial Policy.

At the end of 2016, to meet Brazilian climate commitments, the Ministry of Mines and Energy and entities of the sugarcane segment launched the *"Renova Bio 2030"*, a plan to boost the sector and increase the participation of biofuels in the country's energy matrix by 2030; in the case of ethanol, the goal is to double the production of ethanol from 28 billion to 54 billion liters over that period.

98 http://www.bndes.gov.br/SiteBNDES/export/sites/default/bndes_pt/Galerias/Arquivos/produtos/download/aep_fep/chamada_publica_FEPprospec0311_Quimicos_Relat4_Quimicos_de_renovaveis.pdf

99 https://web.bndes.gov.br/bib/jspui/handle/1408/4283

4 Bioeconomy on the ground in Brazil: ethanol 2G & Braskem I'm green™

Bioenergy policies are strategic for *founding* a bioeconomy: Operating with mandatory blending mandates, biofuels are a strategic engine. Through increasing targets, it serves as a dynamic framework to foster cross sectoral approaches. Currently, 64 countries have biofuel targets or mandates. The bulk of mandates come from the EU-27, where the *Renewable Energy Directive (RED)* specified a 10 % renewable content by 2020 but has been scaled back to the 5 % – 7.5 % range. In the Americas, 13 countries have mandates or targets in place or under consideration, compared to 12 in Asia-Pacific, 11 in Africa and the Indian Ocean, and two from non-EU countries in Europe.

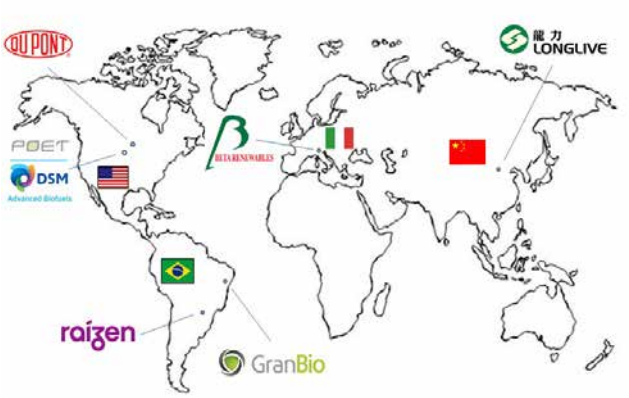
Besides the EU, *the major blending mandates that will drive global demand are those set in the US, China, and Brazil* – each of which has set targets – or, in the case of Brazil, already exist and lie between 15 and 27 % by 2020–2022.[100]

Aiming at diversifying biomass feedstocks, increasing productivity, and developing technology to produce cellulosic ethanol through bioprocessing at scale is considered a major breakthrough to expand the ethanol industry into *second generation* fuel, consolidating it as a commodity product.

Brazil is the world's largest producer of *sugar-cane* ethanol and the second bioethanol producer and exporter behind the United States, which mostly produces *maize*-ethanol. The two countries account for nearly 90 % of global bioethanol production.

In this context, Brazil holds a strategic position: It has companies operating on site with an installed capacity for demonstrative and commercial scale status, land availability and installed productive capacity, and wants to secure a role as an exporter of a value-added product in this next phase. However, despite optimistic forecasts, current developments at a commercial scale that are taking place in Brazil point to a technology capacity for second generation ethanol that is still too limited to meet any significant share of the demand: The production capacity is expected to reach 1% of total ethanol production by 2024. Nonetheless, as countries pave the way for the biofuture, perspectives on the E2G have served to legitimize, promote, and accelerate the further release of GMO varieties of sugarcane and eucalyptus, weakening the protection of biodiversity and rights.

Commercial E2G Plants



Installed capacity of cellulosic ethanol

Region	Installed capacity (million liters)	Percentage of world total
United States	490.37	35%
China	340.19	24%
Canada (wood-based)	303.45	22%
European Union	130.83	9%
Brazil	125.65	9%
World (2015)	1 390.48	100%

Source: UNCTAD, 2016

Ethanol production in Brazil: the historical context

As part of its energy security policy, ethanol fuel policy strategy in Brazil started in the early 70s when, due to the international oil crisis in 1973, the military government initiated a national program – *Pro Alcohol* – to finance ethanol production. The program aimed to phase out a fossil fuel-based fleet in favor of promoting ethanol engines. This required a coordination of efforts through many government sectors, research and innovation bodies, and the widespread engagement of the automotive industry present in the country (including local branches of *Fiat, Volkswagen, GM,* and *Ford*); when the program began to decline, in the late 80s, more than 30 % of the fleet was running on ethanol.

100 http://www.biofuelsdigest.com/bdigest/2016/01/03/biofuels-mandates-around-the-world-2016/

The relaunch of Brazil's ethanol program took place in 2003 alongside the launch of vehicles with *flex-fuel* technology, and became emblematic of the first *Lula* term, creating space for the subject within the broader political agenda of the time, marked by neo-developmentalist policies and state-backed efforts to promote domestic industrial policy. It has also served to clean up the image of the powerful sugarcane sector, earlier known as the "bad guys" of agribusiness, who were rebranded as the new "heroes".[101]

Given the lack of a clear bioeconomy strategy, the biofuels mandate served to connect agriculture, climate/energy, and transport with industrial policies on research, development, and innovation, fostering bottom up linkages of related initiatives and actors across supply chains and markets.

Ethanol is used as a standalone fuel and as an additive to regular gasoline: flex fuel engines, which currently account for 60 % of the national fleet, run on both.[102] The blending mandate for ethanol is currently a 27 % mix in all gasoline sold in the country. For biodiesel, the blend is an 8 % mix for 2017, scheduled to increase to 10 % by 2019 and up to 15 % beyond this date. Soy currently accounts for 80 % of biodiesel production.[103] With 71 million hectares currently under cultivation (2014/2015), government estimates are that the total area planted with crops and fibers (cellulose) will increase to 82 million hectares by 2024/25, mostly due to soy and sugarcane expansion.[104]

Minimizing land impacts with biotechnology

Given this expected increase in demand, a key factor to minimize land requirements is to focus on increasing productivity through accelerating yield gains. While sugarcane production has more than doubled between 2000 and 2013, *88 % of this increase came from the expansion of the sugarcane production area, and only 12 % from yield increase*.

Thus, closing the current exploitable "yield gap" is seen as a high priority for meeting future demand while minimizing pressure on additional land requirements, and addressing associated environmental and social concerns: food security, greenhouse gas emissions, and loss of habitat for biodiversity from direct and indirect land-use change.[105]

To meet this objective, cellulosic based, second-generation biofuels are seen as a major breakthrough: Ethanol produced from the structural and non-edible fractions of plants is called *second generation (E2G)* ethanol. The "ethanol" product is identical to the one obtained from the first generation (E1G) technology already widespread in the Brazilian sugar-cane industry. However, while the E1G technology utilizes only the sugars from cane juice, which represent about a third of the energy available in sugarcane, E2G technology harnesses structural carbohydrates from the bagasse and straw, each one of these fractions representing an additional third of the sugarcane biomass.

Biotechnology has received a major push to harness the "full potential of biomass" and enable cellulosic ethanol production at a commercial scale. In 2015 Brazil approved cultivation of a 20 % higher yielding homegrown eucalyptus plant developed by *FuturaGene* in cooperation with *EMBRAPA*, the national Brazilian company for agricultural research and product & technology development.[106]

The first commercial release of GM sugarcane is expected to occur in the first quarter of 2017, with a variety developed at the *Brazilian Sugarcane Research Center (CTC)*, a top innovation center and the world's largest sugarcane germoplasm bank.[107] According to its promoters, productivity of liters per hectare could more than double with the use of this technology.[108]

Among the resources at its disposal, Brazil lists a consistent pool of research and development institutions and institutions working on the *biochemical value chain* for the production of biofuels (including *CTC, Embrapa/CNPAE, Dedini, Novozymes, CTBE, Petrobras, Fapesp-Bioen,* and *Rede de Hidrólise*).

In Brazil, E2G production sites include two companies operating at a commercial scale:

101 http://www1.folha.uol.com.br/folha/brasil/ult96u90477.shtml
102 http://automotivebusiness.anankecdn.net.br/pdf/pdf_325.pdf
103 http://g1.globo.com/politica/noticia/2016/03/dilma-sanciona-lei-que-aumenta-mistura-do-biodiesel-no-oleo-diesel.html
104 http://www.agricultura.gov.br/arq_editor/PROJECOES_DO_AGRONEGOCIO_2025_WEB.pdf
105 http://bioscience.oxfordjournals.org/content/early/2016/02/12/biosci.biw009.full
106 The publicly owned company has developed and registered an extensive portfolio of international patents, accumulating more than 200 intellectual patents over the years. As it becomes more active in public-private partnerships, this now includes international industry giants, such as *Monsanto*. The first company contract to cooperate commercially with *Monsanto* started as early as 1997. In 2006 *EMBRAPA* opened a regional office in Ghana to base its operations in order to accommodate a larger South-South agriculture and food security cooperation program led by Brazil, which also prominently serves as a platform to support Brazilian agribusiness expansion in the region.
107 http://www.canalrural.com.br/noticias/agricultura/variedade-transgenica-cana-sera-liberada-para-uso-comerial-64892
108 According to *Horizons for Bioethanol* (EPE 2015), while regular Ethanol 1G yields 6,900 liters/hectare, and optimized Ethanol 1G can yield 7,200 liters/hectare (expected by 2020), for second generation, figures point to Ethanol 2G yielding 10,000 liters/hectare and up to 17,000 liters/hectare using the GM variety Energy Cane.

1. *GranBio* (in São Miguel dos Campos, Alagoas, Northeast; 80 million m³/year).[109] *GranBio's Bioflex 1* industrial unit is the first commercial-scale cellulosic ethanol factory in the Southern Hemisphere and has been delivering a steady stream of innovation in the sugar-based alcohol industry since *Proálcool*. The unit became operational in September 2014 and has the capacity to produce 82 million liters of biofuel per year. A combination of technologies (pretreatment, enzymatic hydrolysis, and fermentation) permits the transformation of sugarcane straw and bagasse into 2G ethanol in a zero waste circuit. At the plant, lignin, one of the 2G byproducts, is burned with bagasse to generate electricity. *GranBio* holds a stake in the American clean technology company *American Process Inc., API*, and has access to a proprietary biomass pretreatment platform that makes it possible to develop sugar from cellulose at low cost, and as a raw material for the production of a large variety of renewables. In August 2013, *GranBio* sealed a partnership with the multinational *Rhodia*, a company in the *Solvay* group, to produce chemicals from renewable sources. The objective is to build the world's first plant for bio n-butanol, a key chemical compound in the production of paints and solvents, in Brazil. The two companies test partners' technologies for converting biomass into biochemicals.
2. *Raízen* (Piracicaba, São Paulo, Southeast); 40 million m³/year). *Raizén*, a joint venture between *Shell* and *Cosan* (a Brazilian conglomerate with a strong anchorage in the sugar sector) has built a refinery for the production of 2G-ethanol in Piracicaba, in the state of São Paulo. The plant, commissioned in 2015, has the capacity to produce 40 million liters of ethanol per year, but still works in the experimental mode. According to *Raizén*, four years are foreseen until initial difficulties are overcome and the plant can operate profitably.[110] There is also a demonstration plant operating at *CTC* (São Manoel, SP), producing 3 million m³/year, and a third commercial plant under construction, Abengoa (Pirassununga, São Paulo, Southeast) producing 65 million m³/year.

While, at a global level, the biofuels agenda grew in relevance over the period during which it evolved into a key element of Brazilian foreign policy, its peak came in 2007 when the country launched a Brazil-US partnership regarding a hemispherical ethanol alliance, reflecting geopolitical energy security concerns.[111] Although sidelined in recent years for a variety of reasons, including the flurry of excitement over the discovery of offshore oil fields (*Pre Sal*), Brazil has recently started making efforts to relaunch itself once again as a leader in the biofuels agenda. As the international climate regime is evolving into a major regulatory framework regarding the policy dimensions for building a global bioeconomy, renewable-fuel mandates and low carbon transport standards, as well as fuel targets, directly impact biofuel demand, new markets' perspectives, and long-term investment.

Braskem: „I'm green™"

Created in August 2002 by the merger of six companies from the *Odebrecht Group* and the *Mariani Group* the Brazilian company, today *Braskem*[112] is the largest petrochemical company in the Americas and the world's leading *biopolymer* producer. Today, the 90% of the voting share capital belong to the *Odebrecht* construction group and the state oil company *Petrobras*. *Braskem* has developed into the global leader

Biofuture Platform

The *Biofuture Platform* was launched in late 2016 as a global initiative *"to promote low-carbon fuels and the advanced bioeconomy as an important part of the solution to reduce GHG emissions in transportation and industry"*. Reaffirming the catalyzing role of bioenergy, the initiative aims to *"scale up deployment of modern sustainable low-carbon alternatives to fossil-based solutions in transport fuels, industrial processes, chemicals, plastics and other sectors"*.[i] Nicknamed the "G20 of bioeconomy", along with key governments,[ii] international organizations and mechanisms such as *IRENA, UNCTAD, IEA,* the *FAO,* and *SE4ALL* joined the initiative, as well as private sector associations, such as *WBCSD,* the *Brazilian Association of Industrial Bioeconomy (ABBI),* the *Brazilian Sugarcane Industry Association (UNICA),* and *Below50*[iii]: "a global collaboration that brings together the entire value chain for sustainable fuels – that is, fuels that produce at least 50 % less CO_2 emissions than conventional fossil fuels".[iv]

i http://jornaldiadia.com.br/2016/?p=219427
ii https://www.biofutureplatform.org/launch-statement-1-1/
iii https://www.biofutureplatform.org/launch-statement-1-1/
iv Taking a global strategy and implementing solutions at a local level, *below50* aims to create demand for these fuels and scale up their deployment by: increasing the number of companies choosing *below50* fuels; creating inter-sectoral B2B (business to business) opportunities across supply chains, and addressing legislative and financial barriers to sourcing below50 fuels. http://below50.org

109 http://www.granbio.com.br/
110 http://revistagloborural.globo.com/Noticias/Agricultura/Cana/noticia/2015/07/raizen-etanol-2g-sera-competitivo-so-daqui-quatro-anos.html
111 https://www.oaklandinstitute.org/sites/oaklandinstitute.org/files/biofuels_report.pdf
112 http://www.braskem.com.br/

in the production of so-called "bioplastics" and is dominating the market with its product line and registered trademark *„I'm green™ Polyethylen"*.

But in fact only a part of the plastic can be replaced by biobased resources: the supposedly "green plastic bottles" should reach a level of not more than 30% of biobased resources, in practice the proportion is 15%. So far *Coca Cola* is the most famous user of „bioplastics" - e.g. used for the product brand *Vio Bio*, a bio-certified lemonade of *Coca Cola*.

The raw material base for the bioplastics of *Braskem* is sugar cane, which therefore plays an important role not only in the production of biofuels. All research and experiments with other raw materials, such as algae, have not produced an economically viable alternative to sugar cane. Bioplastic also reproduces the old problems: oil is replaced by the expansion of land use. According to the propaganda of *Braskem* or *Coca Cola* this is not a problem: Without any proof it is alleged that the expansion of sugar cane in Brazil is carried out primarily on *„abandoned grazing land"* and *Coca Cola* proclaims that additional sugar cane cultivation predominantly takes place on *„unused agricultural land „* [113]

„Technology, innovation and sustainability" – according to the propaganda of *Braskem* these are the guidelines of the company. In practice, however, money and corruption seem to play an important role. The main shareholders of the company, *Odebrecht* and *Petrobras*, are also the most important companies in the corruption scandal that has shaken Brazil for several years now. *Braskem* obviously served massively for the payment of "black money". In 2016 the company agreed to a settlement obliging *Braskem* to pay the incredible amount of 3.1 billion Reais, equivalent to 1 billion US $. *Braskem* demonstrates an instructive linkage between old style, fossil-fuel-based industry, corruption and biobased innovation as an extension of the business model.

113 http://www.plantbottle.info/chde/faq/faq.shtml

5 Concluding remarks

While some countries and regions lead on biotechnology, science, and innovation, planning and shaping global trends, others look into ways of positioning themselves to reap the best comparative rewards. As Latin America consolidates its role as a global center for biomass production, a legitimate line of questioning at this stage is *how "bioeconomy-led" alternative schemes of integration could emerge, given the current unprecedented level of concentration of key global industries and sectors intrinsically related to bioeconomy, such as Agtech, energy, and, increasingly, Big Data? What are the contradictions and limitations posed by venturing into a global bioeconomy? How can this global trend serve to legitimize further agribusiness expansion, which is historically violent, rebooting its image from a key driver of social and environmental conflicts to an anchor for development strategy?*

The bioeconomy has been framed as an epochal challenge. Under the constraints of climate change, the engaging narrative of "development" is being renewed to operationalize a political agenda in which the bioeconomic approach appears integrated into a broader set of policies related to green growth, a circular economy, low carbon/climate-resilient development, and the global sustainability agenda of the SDGs. In this context, the transition to a *bioeconomy* offers a consistent narrative, operating a "futuring" effect, laying out a vision to the future of production, work, and the relation between society and nature.

As the global production and consumption system is turning into a major path of rearrangements, biomass is emerging as a strategic asset to be integrated into an evolving knowledge-based economy to feed continuous economic growth. At this point in history, developing countries should not need to follow the same technological course as developed nations. Instead of striving towards the previously assumed path of historical inevitability, that sees urbanization and (fossil fueled) industrialization, entire economies may now leapfrog this stage, moving from agriculture to a high-tech *agroindustry, with* the bioeconomy offering a window of opportunity to prosper for those who anticipate and facilitate this process.

Problems with the dominant view of the bioeconomy point to many areas of concern. While major issues are the direct and indirect impacts of land use change, other variables include water use, impacts of *flexcrop* cultivation, impacts of biotechnology and synthetic biology on biodiversity and health, and increased disputes over natural resources, impacts on rural livelihoods, and rights. [114]

The shifting of strategic resources from fossil to biomass includes major power issues embedded in technologies for programming and manipulating life forms, as posed by synthetic biology, gene editing, and cloud biology. This current process unfolds into an escalating concentration of corporate power in controlling seed and pesticide "compacts" through GMO technology – securing "knowledge-based" intellectual property rights and royalties. Pointing to an even further concentration under the ongoing fusion of Big Data with agriculture, "precision farming" techniques and "climate smart agriculture" rely on collecting data on production, soil, weather, genomics information, tracking, and adjusting seed, fertilizer, and pesticides meter by meter, as well market information and prices. Since the 2000s, farm machinery enterprises have started to link up with GPS and are now connecting with satellites, sensor systems and remote data services at high speed. In the context of the ongoing merging of seed and pesticide majors like *Monsanto* and *Bayer*, farm machinery companies will likely step in to merge Big Data machinery with Big Data genomics. [115]

Reflecting an economic geography increasingly aligned with supply chain configurations and demands, the strategies for securing biomass and biotechnology management on the ground are promoted as an integrated approach. In a globalized economy wired through global value chains, the "opportunity" offered by the bioeconomy takes the global industrial metabolism to a new level.

Serving a global biomass regime in the making, the increased apparatus for overseeing territories raises new concerns, from the privatization of research and data, to cybersecurity and geopolitics. Through the increased scale of "landscape" governance, new layers of power over land emerge with the coupling of larger technological infrastructures over strategic natural resources. Under the "smart mandate", carbon measurement and monitoring over forests and other biomes can serve as a Trojan horse for giant global companies, where corporate actors can exert disproportionate pressure over laws and regulations in this field.

Promoted as the *third* industrial revolution, the bioeconomy threatens to take off from a process of enclosures such as those who set the stage for its prede-

114 https://www.tni.org/en/publication/the-bioeconomy
115 ETC group (2016) http://www.etcgroup.org/content/deere-co-becoming-monsanto-box

cessor. As the idea of a bioeconomy gains traction on the ground, land issues are redefined and amplified. Within the complexity referred to above, a revised debate on the context and meaning of land reform in the 21st century deserves to figure prominently at the core of this century's political agenda, particularly bringing into perspective the simultaneous and multi-level contemporary enclosures.

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