Bio economy's institutional and policy framework for the sustainable development of nature´s ecosystems

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Abstract

This paper has the purpose to offer an institutional and policy framework for the analysis of bio economy implications of sustainable development of nature´s ecosystems. It begins reviewing the elements of bio economics to focus on the research trends methods to support the basic bio-economy method and methodology. Bio-economy is characterized by the creation and efficient use of natural and biological resources, raw materials and capabilities in sustainable infrastructures aimed for the bio production of goods, bio services, bio energy, bio health, etc. to achieve sustainable lifestyles, wealth and economic growth. Finally, this paper supports the argument that bio-economy indicates the limit of the socioeconomic activity for which a biological system could be used without destroying the necessary conditions for its regeneration and therefore its sustainability.

Resumen

Este documento tiene tiene como objetivo ofrecer un marco institucional y de políticas para el análisis de las implicaciones de la bioeconomía en el desarrollo sostenible de los ecosistemas de la naturaleza. Comienza revisando los elementos de la bioeconomía para centrarse en los métodos de las tendencias de investigación para respaldar el método y la metodología de la bioeconomía básica. La bioeconomía se caracteriza por la creación y el uso eficiente de los recursos naturales y biológicos, las materias primas y las capacidades en infraestructuras sostenibles destinadas a la producción biológica de bienes, servicios biológicos, bioenergía, bio salud, etc. para lograr estilos de vida sostenibles, riqueza y crecimiento económico. Finalmente, este trabajo apoya el argumento de que la bioeconomía indica el límite de la actividad socioeconómica para la cual un sistema biológico podría ser utilizado sin destruir las condiciones necesarias para su regeneración y, por lo tanto, su sostenibilidad.

Keywords: Bioeconomy, institutional framework, policy framework, sustainable development, natural ecosystems.
JEL: 013, 013, 044, Q02, Q03

1. Introduction

According to Foucault (2003), human species has been conceived of as a bio-economic problem since the beginning of capitalism despite the considerations on its biological, economic and social conditions. The sustainability of bio-economy remains as uncertainty and bio-economy challenge to deal with the environment issues (Batie, 2008; McCann, 2013).

It has been considered a myth that bio-economy promotes solutions of sustainable problems by substituting fossil resources by biomass raw material (Pfau, Hagens, Dankbaar, Smits, 2014). Sustainable growth from sustainable bio-economy plays a key role in reaching a resource-efficient and low-carbon sustainable economy. Sustainable bio-economy development addresses societal and economic challenges related to sustainable economic development on issues such as climate warming and fossil resources, natural resource scarcity, biomass competition, biodiversity, waste streams, governance, social well-being, etc. Former waste streams from one process are the raw materials for next process on the bio-economy web.

Not all the challenges can be solved at once (Philippidis, M'barek, and Ferrari, 20162016). It is relevant to identify bio-economy processes to achieve potential gains, benefits and values addressing the scientific, biological, economic, governance, etc., issues. A governance framework is required for a transition to a bio-economy to be a sustainable one.

Coordination of different policy areas impacting bio-economy provides an effective institutional governance framework. Dividing the bio-economy activities in sectors fails the integration and convergence of research and technology development, infrastructure and governance practices. Creating coherence between bio-economy´s policy framework and other different policy areas and measures are necessary for a good governance and require action. Two barriers for governance are the institutional fragmentation and incoherence (Loorbach 2010).

2. Institutional framework

Bio-economy is influenced by uncertainties such as fossil fuel services, regulations on climate change, biomass available, etc. The system of organization relates the modes of regulation and development with their degree of complexity. Bio-economy promises to solve problems for humanity by supporting sustainable economic growth, using natural renewable resources rationally, taking care of the environment, preventing climate change, and so forth, activities that require

collaborative institutions, policies and knowledge. Institutional, legal and regulatory policy framework is more conducive to bio-economy development.

An essential element for a framework of bio-economy of implementation is the integration and coordination of patterns of bio-economic activities at local, state, regional and global levels, despite the geographic, institutional and cultural differences. Economic theory is grounded in biophysical reality where the human is a biological specie bound by biophysical processes and social beings shaped by institutional patterns.

Institutional regulations and policies are an important factor of bio-economy development to stablish the environmental and human development standards for the use of waste resources, bio production, bio distribution and bio consumption. The regulatory framework is critical for the research, development and innovation in bio-economy for all the sectors involved in the bio-economy web in these practices. The participation of governments with better regulatory frameworks, companies, civil society, communities, citizens with higher levels of investment, research institutions and higher education is crucial for the development of bio-economics innovation. Reference is made to a force exerted by the government to regulate the population through the application of the political power in all aspects of life. That political power is reflected even in the green spaces of the cities.

For government, bio-economy is the part of economics using biological resources, biomass, and bioprocesses for the production of value added bio based products. Under the German approach, the government had a monopoly on city planning, which it considered to be an important part of the strength of its country. Other governments have addressed the need to streamline activities, from the hierarchy of vehicular and pedestrian fluids to the street layout, but also fostered special spaces for certain activities, and at the same time encouraged the participation of government and citizenship bodies in the processes of rearrangement, motivating collective actions and used instruments such as expropriation and land control in order to facilitate the processes.

Bio-economy systems at national level are dependent on global economic developments, global trade patterns and regulations, sustainable and climate protection issues. Legal and regulatory frameworks may facilitate organizational transitions towards a more bio economy-oriented activity in the market place and become positioned in a market share. Economic structure decisions on bio-economy demand and supply of products determine the growth and limitations of the bio-economy system and biomass production (Hoefnagels, Dornburg, Faaij, Banse, 2015) and further more biomass demand from other sectors such as bioenergy requiring technological development has an impact on regulations of the market.

Governmental institutions at all decision levels have a vital role in the creation and development of bio-economy environments where the contributions of academic and research institutions can find and implement new biotechnologies. In regulating the activities of the bio-economics project, biotechnology such as bio-pharming plays a relevant role in the transition processes of the neoliberal economic system. The Bio-economy is promoted by biotechnology research in the context of industrial sectors with partnerships in the scientific community and funded by public and governmental institutions is application oriented with immediate results.

Research base in biological, environmental, economic, social, chemical sciences and engineering sciences supported by institutional infrastructure and supportive mechanisms aimed to achieve world-leading breakthroughs provide opportunities for the development of bio-economy. Advisory services in bio-economy can be provided by governmental and scientific institutions. Eco services focus on social entrepreneurship and relates natural environments to public goods and benefits agriculture, forestry, marina and food networks.

The needs of a sustainable bio-economy depend on exploitation if biomass resources supported by appropriate international legislation and institutions. In progressive evolution, institutions emerge as an exomatic feature and the production of exomatic organs is completely dependent upon people. Bio-economic Pressure (BEP) is the exosomatic energy demanded and consumed per unit of working time allocated in the primary sectors of the economy.

A research project structure considers the current state of bio-economy, trends, key drivers, emerging business models and institutional, legal and regulatory policy. A challenge for research institutions, government and firms is measuring the results of bio-economy sustainability require indicators to elaborate the reports. Economic institutions of beekeeping are useful to analyze the bio-economic of management of livestock economics and domestication of species. Champetier, Sumner and Wilen (2010) developed a bio-economic model of beekeeping to explain the dynamics if bee population in terms of biological and economic factors. The model developed was designed for honey bee management under a wide scope of the bio-economic approach, as the authors recognize.

Societal support to complete the bio-economy processes and to dismiss the social fears and concerns need to be addressed an overcome in a global context. Bio-economy is a key element for solving societal challenges and active-lifestyle orientation. Integration of bio-economics with society and business in a more cooperative approach is becoming more efficient not only as a sustainable creator of employment conducted until now at national level, but to address the societal challenges.

Firms, social advocacy movements, societal groups counterbalance the fossil-based market In 1976 Georgescu-Roegen developed a comprehensive theory of bio-economics framed by economy, society and biophysical constraints of social organization of economic activity. The main argument was that economic activity and decisions should be based on biophysical and social context of consumption and production beyond the market exchanges. Development of bio-economy is sustained for the approach for a whole system to achieve sustainable bio-economy and the cycle life consumption to reduce societal consumption and to implement a bio-based production where the end of the life of one product is the raw material for the beginning of new bio-product. From the bio-economy activities, lifecycle assessments as a tool contributes to sustainability, to analyze the implications and impacts.

The bio-economy is fundamental for the transformation of societies, since it develops under the premise of sustainable consumption and production. Bio-economics as the economy of the third path promises to be the foundation for the sustainability of society and companies, surpassing the model of destructive competitiveness centered on the survival of the strongest and exclusive extraction of natural resources.

The creation of wealth through bio-economic capitalism, which in a long-term constructive way tends to eliminate externalities and to develop a more just and egalitarian society, homogenizing income and forming spiritual values. A good example is the city that was designed to conform to the principles of a society logic, or at least some attempts were made to order it. Green areas are designed to decontaminate and generate value in cities. Although they are areas in charge of providing society with a clean space where they can have contact with nature, they leave the visual contamination and contribute to the environmental requirements set forth by the World Health Organization (WHO) (SEMADET, 2013a, 2013b).

To evaluate the potential impact of biosciences and biotechnology applications in bio-economy at society-wide level. Bio-economy is a new opportunity facing some of the society´s challenges such as converting feedstock and waste resources into providing high value sustainable resources and bio products.

The institutional bio-economy is based on the institutionalization of non-economic components such as empathy, solidarity and compassion. The forms of adaptability of rural spaces on the periphery of cities must be classified as micro-social processes of conurbation, which demands increasingly efficient and legitimate responses, and imply the increase of local capacities in terms of foresight and strategic thinking for the development approach by the institutions and their upward concreteness in community development. Social adaptability is understood as the capacity of social agents to act, effectively and jointly, on the basis of a conception agreed upon

and fostered by consensus between different levels and sectors of the institutional apparatus. To propose to characterize the adaptability capacities of the rural spaces and settlers, following for this the premises that feed the evaluation processes of the European policy of rural development namely (Comisión European para la Agricultura y el Desarrollo Rural, 2014):

Future developments of bio-economy is dependent upon institutional and technological developments.

3. Policy framework

Bio-economy is a new concept to be integrated into policy (Levidow *et al.)* and into strategy. Bio-economy strategies foster the policy strategies process. Bio-economy is a strategic option in a comprehensive economic policy development and regulated according to their specific sectors (Bundesministerium für Ernährung und Landwirtschaft, BMEL 2016). Transition towards a bio economy should be supported by policy instruments to achieve a sustainable economy and political stability.

Bio-economy set policy recommendations to address future societal challenges on sustainable ecosystems, global food security, creation of smart bio products and biofuels, development across all sectors, from agriculture and manufacturing and bioenergy. To assess public policy issues encouraging research and innovation, removing barriers and forming strategic cooperation relationships and alliances between the different stakeholders and economic agents.

As reported previously by OECD (2009a) inform some political events may influence the development of bio-economy such as the quality of governance or the system of regulations and policies and the economic competitiveness of biotechnological innovations. A policy agenda on bio-economics requires a framework for cooperation relationships between different institutions, technological and economic sectors, including society, business and government. The current bio-economy agenda is creating some developmental problems that could lead to a failure, if the lessons from the past are not recognized, learned and adjusted, as the damage caused in the case of the agro fuel.

The bio-economy is a strategy of cooperation between different sectors, and coordination between stakeholders and policies, academics and civil society as it has been stablished in 2013 in The European Bio-economy Panel. Also, multilateral initiatives in knowledge-based bio-economy strengthens policy research.

A. Policy formulation

Policy formulation and development and investments are required for an effective bio-economy innovation system based on circular economy. Bio-economy activities are growing in the biosciences in some countries faster than others. Policy decisions on creating a high value bio-economy should focus on waste feedstock has an economic potential for the bio-economy including industrial biotechnology. The bio-economic spatial policies are different from any spatial policy in terms of both their application and their performance. The consequences of this urban growth can be observed in urban sprawl. In developing countries, however, urban sprawl is aggravated by the lack of city planning and the lack of public policies to regulate urban growth. Since the 1950s, in most Latin-American cities have experienced intense growth due to the industrialization of the country, and since 2001, policies have been implemented to prevent disordered urban development.

Bio-economy needs more flexible coordination and integration of efforts among academics, stakeholders, policymakers, etc., conducive on a bio-economy web to become more sustainable from the raw materials to the residues. Technologies platforms, such as the European (ETPs) are supporting structures of collaboration policies to provide a framework for bio-economy organizations to further develop the concept. In Berlin in November 2015, the World Bio-economics Summit is held as the "first platform to generate community and discuss bio-economics policies globally" (GBS, 2015).

Biological resources and raw materials for bio production offer a potential to address societal challenges with the collaboration of all stakeholders involved in policy making for the implementation of bio-economy as the driving force. Resources of bio-economy can minimize threats to human health, improve nutrition, developing foods, reducing GHG emissions, etc.

The different stakeholders participating and cooperating in the bio-economy web platform should have an important role in gathering, sharing and spreading information and communication on bio-economy issues. Bio-economy developments have some communication and understanding implications to improve the social image across the various economic and industrial sectors and stakeholders and increase scientific and technological awareness. The success of the bio-economy is likely to depend on active participation in both policy-making and specific projects. The agro energy policy has limited impact in less developed countries where the bio-economy's development is in its early stages (Paul, 2013). The focus of bio-economy on agro fuels has have until now negative impacts on economics, social and environment.

B. Influential factors

The identification of the factors that influence the development of the bio-economy acts as the basis for establishing the vision and objectives of a transition to a bio-friendly economy.
When uncertainties are high having an impact on the bio-economy and is considered as a policy to identify the influence of factors and the different future options. External influence factors can act as levers for steering the development of the bio-economy. Influential external factors are considered active factors for the potential they have an impact on the development of bio-economy systems, such as the demand for energy from biomass driven by climate policies affecting raw materials and fossil energy, such as the case of policies affecting the energy efficiency.

Initiatives of policy making, market agents and other external factors such as international trade, climate change, innovation and technologies, new discoveries of fossil resources, etc., have an impact on the availability of natural and biological resources and biomass raw materials, vital for bio-economy development. Policy making and inter dependencies with international trade agreements and energy and climate policies are determinant for the relevance of future bio-economy scenarios and bio market expansion.

The bio-economy development is influenced by government policies and regulations enacted to resolve different crises caused by scarcity of resources, shortages of food and water, finances, etc. Scarcity of mineral resources and the shortage of energy limit the survival of humanity. The role of government besides the policy and regulation framework, provides sufficient funding programs for the use of biomass use (Carus, Carrez, Kaeb, Venus *2014)* and natural resources. Bio production using the framework of bio-economy should have the same policies and regulations to be managed equitably under the same framework of development and incentives.

Bio-economy progress in technology and commerce is outpacing the policy and regulatory frameworks and urging governments to design the bio-economy policy agenda. However, the European Union's bio-economic agenda is more oriented towards the sustainability of the processes and functions of ecosystems and natural resources in terms of environmental impacts through interventionist policies of governments.

The bio-economy is related to nature and natural environments. Biological resources and the natural environment are intrinsic to the socioeconomic system and not incidental. They are not gifts from our ancestors to abuse and destroy, but should be seen as loans to use and care, to pass them on to generations to come. As a factor of production, they are essential for the production

process, because the genres of use that originate them, are different from those that originate the traditional factors of production and also generate increasing returns.

Production-based bio-economy requires influence factors from a bio-economic systemic perspective (Dewatripont, Roland, 1995; Advancing renewable energy policy in Europe 1997). Key actors and other influence factors in bio-economy based activities are identified and design bio-economy scenarios (Carus, Carrez, Kaeb, Venus, 2014). An analysis of bio-economy scenarios consists of an status quo analysis, identification and characterization of influence factors, formulation of projections and design of scenarios. Projections of the influence factors on the bio-economy system may result on favorable developments (European Commission (2014). Innovative, Sustainable and Inclusive Bio-economy, 2014).

The most influential factors are characterized, defined and explained in the role and function in the bio-economy system. However, despite that the influences are important for the development of the bio-economy, they also have influences other factors, but they are also subject to strong influences from the bio-economy system itself. The behavior of economic agents as investors, firms, consumers, etc. and political actors such as the State, social movements, communities, etc. play important roles for the bio-economy to be considered as friendly or adverse attitudes and combine them with projections. Political support for the bio-economy may cause a rising costs.

Sustainable bio-economic growth accounts for traditional factors and new factors of production. Thus, the bio-economy recognizes the non-economic intangible values of biological, environmental and socioeconomic reality (Mohammadian, 2003). The influential factors on development of the bio-economy may not be distinct in different sectors. The wood-based bio-economy has potential influence factors for future development around the world, although in some countries, like Germany, for higher growth

When examining the factors and constraints, as well as the positive and negative effects of the bio-economy, it is necessary to make a distinction between the current situation and the near future rather than the long-term future is based more on visions and ideas.

C. Policy implementation

To implement a policy based on bio-economy and accelerate application of basic technology requires coordination and cooperation of all the actors, stakeholders and agents involved in in research and development. To design and implement sustainable bio-economy plans

is it is required to develop training programs in all related areas of production, logistics and distribution, marketing, etc. according to the policies to improve economic, environmental, human and social outcomes.

Gradual implementation of policy instruments has higher impacts on bio-economy than the rushed full introduction. Policy coordination between regions can address issues of coherence in the development of bio-economy and foster innovation. Policy coherence and collaboration within and between nations can be maximized at regional bio-economy level. Faced with increasing scarcity of resources, bio-economic policy must consider demand and reduce waste. Policy instruments implemented to increase the demand and supply of bio-economy-based raw materials and bio-based products may lead to lacking political support and pressure groups to stablish new measures in the bio-economy market. Lacking of a bio-economy policy only shows the prevalence of traditional markets and the marginality of bio-economics (Pannicke, Gawel, Hagemann, Purkus, Strunz, 2015).

To have solutions that governments can apply to problems and a variety of policies and activities on bio-economy development requires an assessment of policy based issues and prospects facing bio-economy and bio based applications.

4. Elements of bio-economy

Bio-economics combines elements of evolutionary biology, conventional economics and biophysical analysis (Miernyk1999) although the existence of humanity is not only dominated by biology or economics. The elements of the bio-economy are the renewable biomass, converging technologies and integration in production. The bio-economy combines use of renewable bio-based natural resources with environmental clean technologies in primary production and markets and efficient material recycling. Bio-economy aims the management, development, production and use of renewable biological resources, processes and products on equilibrium with human economic activities. Bio-economy industry provides diverse supplies of bio-products, fuels, renewable energy, power, health, etc.

A. renewable biomass

Bio-economics as a science deals with the use of biological resources in a sustainable way in ecosystems and with the efficiency of the economy for the production of renewable biological resources or biomass to develop bio products, biofuels, bioenergy, etc. The implementation

processes of the bio-economy with emphasis on biological and natural renewable resources through biotechnologies support the sustainable global economy. The bio-economy covers the production and use of renewable biological resources, economic activities of a country or between countries, related to the invention, development, production and use of biological products and processes (European Bio-economics Panel).

Bio-economy is based on renewable natural resources to produce food, energy, and other products and services. Bio-economy use renewable biological resources from sea and land to produce food, energy, materials, etc. Biomasses from renewable natural resources offer solutions to meet human needs. The basic components of raw materials, chemicals and energy derive from renewable natural biological resources (McCormick and Kautto, 2013). The bio-economy as a transition away from an economy based on fossil-based resources, uses agricultural, forestry, marine and waste management resources towards the production of biomass and renewable resources into food, energy, health, biofuels and other based products.

Bio economics begun with rural-urban food chains and food banks promoting green diets. Integrated bio-economy secures transition to sustainable future by creating biomass as a renewable raw material for bio production and food security provided by agriculture. Bio-economy implies the capacity to develop a long term vision for the future use of bioenergy and bio resources, the production of renewable biological resources or biomass to provide more food security and a better life conditions to future generations. Sustainable bio-economy supports a transition from fossil economy to an exploitation of renewable natural resources and biomasses produced by forests, waters and fields. In some countries such as Finland, bio-economy relies in forests based on sustainable exploitation.

Bio-economics uses renewable biological resources to produce food, bio-energy, bio-materials and bio-products. Bio-economy uses renewable resources of plant materials to substitute fossil resources. The Bio-economy is a framework to develop and to use by-products from one sector into other one if they cannot be used directly, giving more opportunities for balancing and improving the use efficiency of natural renewable resources. Renewable energies increase the demand for bioenergy.

The benefits of bio-economy and bio based products are well documented somewhere else such as biofuel-based products, bi-power, renewable chemicals (USDA 2014a; Bio-economy Research Associates, 2009; IEA 2011, USDA 2014b). There are already available some uses of bio-economy for renewable energy to meet the demand of markets in the event of future price volatility in global fuel supply with an efficient and system of distribution, transport and delivery to the final users. Bio-economy helps to mitigate challenges associated with natural renewable

resources, greener environment, and public health. Bio-economy sustainability increases the diversity of energy and security providing economic, social and environmental benefits.

The European bio-economy in 2030 White Paper contends that the renewable biomass encompasses any biological materials in agriculture, forestry and animal-based including fish, as a product in itself or as raw material to be used for other goods. The White Paper on Renewable natural resources from agriculture, forestry, aquaculture and marine ecosystems are considered the roots of bio-economy. The impact of the global bio-economy agenda is estimated to be positive because it promotes sustainable bio production of renewable natural resources, which in turn protects the environment, generates economic growth by employing labor in biotechnology, agriculture, etc.

B. Converging technologies and biotechnology

The approach on social economics of entropy and bio-economics grounded in human embeddedness with social and physical universe is increasingly accepted (Gowdy, and Mesner, 1998; Gowdy and McDaniel 1995; Dasgupta 1995). Humankind is a contributor to entropic degradation by the increasing extraction of natural resources and elimination of wastes into the environment. Georgescu-Roegen exposed the insights on agrarian economics (Georgescu-Roegen 1960; 1965a) observing that entropic degradation is a constraint of any economic activity and that the survival of humankind depends upon scarce resources. These assumptions laid the foundation for the emerging field of bio-economics and ecological economics.

Bio-economics is an approach to the so-called new economy that promotes competitiveness and economic growth through the use of technological resources for the exploitation of natural resources and living matter (Birch, 2006). The bio-economics ensures long term economic and environmental sustainability. Bio-economic analysis provided a framework to explain the relationships between economic, social, political and ecological implications of human-natural resources. Bio-economic analyses are based on the premise that environmental and natural resources contribute to human development and social wellbeing.

The bio-economy is based on new biotechnologies and biogenetics is considered as a revolutionary economy that manipulates, transforms, exploits and appropriates biological material (OECD, 2009b). The bio-economy is a hyper-technological phase of the new industrial revolution oriented by economic, social and environmental sustainability. The bio-economy supports biotechnologies and biomass for the development of new bio products derived from biological organisms and plant and animal matter. The bio-economics of assisted reproduction through

biotechnological processes are considered to be replacing traditional economic processes and to a lesser extent the pharmaceutical industry (Hopkins, Martin, Nightingale, Kraft and Mahdi 2007).

The development of bio-economy-related technologies in the different engineering sectors provides entrepreneurial opportunities for the creation of new business. Bio-economy is transforming and adjusting the concept of business to reduce the risks while becoming more competitive in the future. Bio-economy offers business development opportunities of biomass and water resources exploitation and technologies associated to obtain high added value products and services. Food, health and energy industries are fast developing bio-economy business. Bio refineries and flagship technologies are vital for the development of bio-economy

Biomass resources are transformed into products in demand that yield the highest added value enable by technological advancements laying the foundation for a sustainable bio-economy Living according to the terms of nature, availability and scarcity of natural resources and adapting friendly technologies. Bio-economy activities are developing in sectors such as technology industry, food, health, energy, civil engineering, pharmaceutical industry, clothes industry, printing and design, planning and expert services. The bio-economy is based on the creation of wealth in the continuous growth of socio-economic activity with the least loss of diversity, less possible ecological damage to the environment and with a social justice balance, so as to ensure the capacity for regeneration of natural and biological capital.

Bio-economy includes the study of biotechnology, environmental technology, ecology, agriculture, forestry, fisheries, pulp and paper, construction, chemicals and pharmaceuticals, food processing, textiles, industrial goods, recycling and waste collection. Although the study of bio-economy attracts to new students, companies across bio-economy sector have trouble to employ skilled professionals. Bio-economy is contributing to develop biotechnology based products and their economic and environmental benefits (OECD, 2009a). Bio-economy is closely related to biotechnologies considered as processes that use and biological systems and organisms to develop new products and biomass or material produced from vegetable or animal materials.

Agribusiness with bio-economics orientation are based on options of products not so much generic or commodities but more on differentiated products that are exposed to the risks of the market and biotechnology. Of course, prices have greater volatility in bio-economic products and services than in generics.

The OECD argues that biotechnology can offer solutions to many of the health and natural resources facing the world, and also proposes that advanced bio-economics and biotechnology will drive significant changes in the world economy over the next 30 years. Biotechnology production

and biopharmaceutical products are well located in German bio-economy among the industrial sectors and integrated with health research. Bio-economy and health research results can be integrated with comprehensive support initiatives.

While there is a growing research and development effort, the deployment of technologies in advanced bio-economics is a reality. The costs of conversion technologies in the development of bio-economy is one uncertainty (Hoefnagels, Dornburg, Faaij, Banse, 2015). Bio-economy research supported by the access to up-to-date statistics information system should be incorporated to the decision making processes for the provision of new economic services on the bases of sustainable biomasses uses and safeguarding ecosystems services.

Emerging biotechnologies contribute to the bio-economy through the bio-production of bio foods, bio health, bioenergy and bio-based products. The development of biotechnologies contributes to the bio-economy by providing commercially bio-based products. Technological progress in bio-economy must serve humanity and the needs of people who may participate in the implementation processes in the different industries. The concept of a bio-economy creates the transformations in socio-technical systems (McCormick and Kautto, 2013). To realize the potential of bio-economy safety issues should be addressed in relation to biotechnology that affects positively or negatively human health and welfare.

C. Bio production

The term bio-economy is related to the role of sustainable biomass. Bio-economy is also named bio-based economy, although bio-economy refers to food and feed chains and bio-based economy refers to the bio products of non-food goods. However, bio economy is more useful term to mean both the use of food and feed, and the bio producción. Also, aquatic biomass expands production for the bio-economy. Bio-economy activities are connected with sustainability inherently fossil-free shifting away from oil-based production and using more biomass and bio-based materials where no waste is produced. Bio-economics is the set of economic activities that obtain products and services, generating economic value, using, as fundamental elements, resources of biological origin, in an efficient and sustainable way. In bio-economics, viability is a concept that implies time, context, and the nature of economic value.

Entropy measures unavailable energy of the system. Bio-economic human beings always face the right choice of the suitable rate of increase in entropy in the long term. The explanation of the mechanism of this process indicates that the human species transforms natural resources with low entropy, and the mechanism makes them products and waste of high entropy. The Entropy Law

is described as the most economic in nature of all natural laws" and "the taproot of economic scarcity. An increase in entropy is considered negative for bio-economic human beings. Bio-economic beings are dependable of flows of economic activities with inputs of low-entropy scarce resources and a shortage of energy go into the economic process having outputs of high entropy waste from it.

The social importance of bio-economics seeks to facilitate access to basic services. Economic adaptability of bio economy is understood as the ability of social actors to produce and maintain maximum value over productive capacity in the territory, by strengthening links between sectors, combining assets to enhance the specific character of local products and services.

There are divergent views of the bio-economics from very optimistic about an industrial revolution in the coming decades to a serious concern about possible major negative impacts, especially related to agriculture and food production. Humans transgress biological evolution by manufacturing exosomatic production evolved into an economic process to replace the inherited one. The economic process is an entropic transformation where the true product of the economic process is an immaterial flux, the enjoyment of life, whose relation with the entropic transformation of matter-energy is still wrapped in mystery. (Georgescu-Roegen 1976a: xiv). According to The European bio-economy in 2030 White paper, the Bio-economy refers to the sustainable production and conversion of biomass into a range of food, health, fiber and industrial products and energy.

One of the objectives of bio-economy is to integrate economics and environmental sciences associated with the use and conversion of biomass to bio production. The premise of bio economy is based on achieving a balance between economic activities and the use and management of biological natural resources. The Bio-economy addresses some major environmental, economic and social changes for sustainable production and transformation of biomass material for better living and working. Integrated bio-economy provides better living conditions for a sustainable human development, better food, raw material for bioenergy and bio products while halving the environmental impact.

Bio-economy growth has an impact on the raw material input value added and bio-economy output value added produced for natural resource as well as the total use of natural resources growth and harvested volumes of biomasses and in terms of ecosystems services. The wood-based bio-economy, also referred as sustainable bio-based economy on woody biomass, is supported by the biological natural resources and the economic sector to develop sustainable products and services.

The fundamental principles of the sustainable bio-economy focus on food security, consider the reproductive capacity of crops, the use of biomass, and reduce, recycle and reuse waste and diversification of bio products and production systems (Standing Committee on Agricultural Research, 2015). Bio-economy saves natural resources by recycling and re-using them.

Bio-based products and market development is essential to bio-economy development and needs to be prioritize. The impact of biological processes and seasonal cycles on economic activity, "the biological has burst through its economic shell" (Georgescu-Roegen 1965a: 226). Global market based on global economic processes promote the development of bio-economic satisfactors, products and services. Bio-economy is becoming a relevant and growing part of the global economy by providing bio products and energy. Bio-economy business requires a competitive and efficient operating and investment environment and a market place demanding bio-economy products and services and global solutions. Indigenous agriculture and forestry are a feed supply engaging investments and local communities for bio-economy. Bio-economy has growth opportunities when there are forest resources exceeding the harvested.

Bio-economy responds to current developments and challenges in global economics, social and environmental issues. Bio economic and environmental analysis are strongly correlated. Bio-economy has a relevant contribution to economic growth with the production of multiple public and social goods such as supplies in food, energy, coastal, rural production, and conservation of natural and biodiversity environments. There are some value opportunities in bio-economy from producing high value products from using waste resources and feedstock. Bio-based products are products that are wholly or partly derived from materials of biological resources origin, excluding materials embedded in geological formations and/or fossilized.

The sustainable production of biomass-based products potentially reduce greenhouse gas emissions using multifunctional landscapes to improve ecosystems and environmental services such as the quality and health of water and soil, including other natural resources and optimizing of land use, soil erosion, etc. Some other economic benefits of the bio-economy are in terms of job creation, increase in economic mainly in biomass production with an impact in all sectors of the economy but mostly in rural development, agriculture, forestry, aquaculture, service sectors such as logistics and distribution, etc.

The agricultural bio-economy is based on transgenic plants and products. The bio-economics is the basis for entrepreneurship of agricultural businesses that produce food and other types of non-food products such as biomedicine biofuels bioplastics, bio paints, etc. A project to evaluate in the Bio-economics can be the production of vegetables that can help to prevent the diseases, as the tomato with more lycopene content is supposed to prevent prostate cancer.

Sustainable management of natural biological resources are the means of production for the bio-economy. Bio-economics is the science that aims at the management of sustainability in order to achieve sustainable socio-economic development, through the management and efficient use of natural resources. Bio-economics is considered a poietic economy because it imitates not only theory but also in practice the economy of the rhythms of nature.

Bio-economics has also major hurdles such as to develop cost-benefit competitive biomass-derives bio products, reducing environmental risks and negative impacts on infrastructure and investments, natural resources scarcity, lack of transportation and distribution facilities and channels. Large corporations usually profit from bio-economy activities and do not necessarily address the native impacts on food security and bio products. There is a higher risk in bio-economy developments such as on new disruptive bio-economy sustainable products. The potential and prospects of bio-economy as a niche sector are highly valued despite the risks of sustainability by inducing fossil-based processes and products substitution.

5. Bio economic research trends

Bio-economics is a science based on a synthesis of biology and economy (Belhoutchette et al. 2011; Sundar 2012). Research is an important lever for bio-economy development. Professionals involved in bio-economy research, product development and commercialization activities need a clear, open, accurate and transparent communication to change the public and social perception in the benefits and advantages to implement bio-economy programs.

Some bio-economy research trends are more related to consumption patterns, climate change, eco-technologies, raw materials scarcity, innovative products, etc. Bio-economy lays the foundations for global development based on renewable natural resources to increase growth, reverse declining natural resources, protect biodiversity and stabilize climate change. “the use of biomass offers solutions to many of the problems of the fossil-input-based economy: it ensures both energy diversity and security and is environmentally friendly, owing to carbon sequestration and the resulting climate change mitigation” (Vandermeulen, van der Stehen, Stevens; van Huylenbroeck, 2012: p. 454).

A. Consumption patterns

Consumer behavior drives bio-economy to secure achievement of human well-being. The dominant view of the bio-economy threatens balanced consumption by profitable consumption and social justice because of the asymmetries of access to renewable resources.

A bio-economy system has to transform the consumption behavior. The impact of the whole system from bio product consumption is the basis to consider if biomass is sustainable or not (Paterman, 2014). Bio-economy provides products, services and components environmentally friendly, reduction of weight, although the consumer awareness and the acceptance are low mainly due to the lack of communication. Bio economy sectors in economic activities has increased in wood-based industry, consumer goods industry, bio-based plastics, energy, etc. Bio-economy is not restricted to waste feedstocks which also takes on process and harvest residues not produced as bio products but as by-products, co-products and biogenic components of industrial and consumer biodegradable bio-waste.

Bio-economics is also an instrument of economic analysis. According to Brambila Paz and Pérez Cerecedo (2011), the bio-economy as the economy based on biology, is the production and distribution of the goods and services that are obtained from the directed transmutation of living beings and their substances (plants, animals, bacteria, viruses, enzymes) to meet the individual needs of the consumer (the human being) according to their characteristics and circumstances. At the core of bio-economy are the living beings. The dominant approach to bio-economics is the perspective of life sciences that attempts to correct dysfunctional behavior and destructive patterns, but unfortunately promotes the growth of consumption and exploitation in the market for bio products and bio cognition.

The bio-economy agenda prioritize market grow instead that environmental health and social wellbeing based on increasing the use of biotechnologies and biofuels while ignoring the reduction of consumption as the main cause of resource depletion leading to unsustainable use and management. Bio based goods are consumed directly or to suppliers of agro-feedstock. Bio-economy consumers are sensitive and demanding at the bio-business on bio products related to food, health, quality and fresh produce. Human as biophysical and social being is dependent on available and usable energy. Bio-economy offers an alternative to the consumption of energy and other renewable materials based on the processing of agricultural production. The world's economy should shift from one based on stocks to one based on the flow of solar energy and agro energy (Paul, 2013).

The bio-economics agenda prioritizes finding alternatives to fossil fuel consumption and increasing consumption and market growth rather than improving environmental conditions, health and social welfare. An integrated web of systems and networks using biological resources adaptable to change and resilient is the base of bio-economy to enable development support and maximize value creation. The logistics and physical distribution of satisfiers, bio-economic products and services requires a value network that distributes and reaches the end consumers, strictly attached to sustainability, without pollution or destruction of natural environmental resources, with social responsibility and respect for humanity.

This area is involved in the production and commercialization of food, as well as forest products, bio products and bioenergy, obtained through physical, chemical, biochemical or biological transformations of organic matter not destined for human or animal consumption and involving processes that respect the environment, as well as the development of rural environments.

Bio-economy has potentials to develop given the required consumer needs and political conditions. Sustainable bio-economy business and agents must be able to take advantage of market opportunities and communicate the best sustainability practices of their products and services with emphasis in material and immaterial consumption choices.

B. Climate change

Many of the problems that bio-economics tries to solve such as climate change, pollution in its various manifestations are caused by the economy. A solution to the economic, human, natural and environmental crisis, as well as to the challenges posed by the scarcity of natural resources, polluting fuels, climate change, food insecurity, etc., is the solution presented by the bio-economics as a science. The bio-economy contributes to increasing the efficiency of renewable resources and mitigating the ravages of climate change.

For the specific case of Germany, the Federal Council of Bio-economics promotes the recommendation of research for climate change, bio production of biofuels, biotechnology, bioenergy, biofuels, bio agriculture, etc. (National Non-Food Crops Center, 2015, EuropaBio, 2008). The agricultural production systems research requires appropriately bio-economy diversity with the integration of genetic resources through funding. Several research studies show that green spaces can mitigate the effects of urbanization and benefit the climate, soil, air and water.

6. Basic bio-economy method and modelling

Bio-economics offers a new epistemology to investigate the socioeconomic system in association with the biological system as a whole, and to study the nonlinear interactions between its components and not just between the characteristics of individual components (Mohammadian, 2005). The main objective is to bridge the gap between the empirical science of biology and the literary science of economics and end the disunity and separation of the two cultures.

Bio-economics as a science develops its own theoretical and methodological principles and foundations different from the science of economics. From the theoretical-methodological perspective, the bio-economics practices are biological, economic, social and environmental often in conflict with the market economy. Bio-economics methodology integrates a dynamic interrelationship between natural-human and socioeconomic values into biophysical analyses. Some features of thermodynamics are qualitative change, irreversibility, indeterminateness, and true scarcity.

Sustainable bio-economy raw materials and natural products markets supported by sustainable biotechnologies and operating models are the base for a sustainable bio-economy development. The creation and development of new products based on business models that are based on the bio-economy entails facing more complex and uncertain business environments. The bio-economic model reconciles and harmonizes the logics of economic, human and natural processes with their different organizational forms. From this perspective, the model of development centered on the bio-economy, returns to consider the natural systems separated from the laws of the market but integrated to the economic activities.

Models and data in bio-economy are developed and used to optimize decisions related with quantify tradeoffs and synergies and minimize adverse impacts in economic, environmental, and social benefits. Multi partner collaborative efforts are required to create and develop sustainable bio-economy models. Bio-economic models are used to quantify human ecosystems for production, distribution and consumption activities (Braat and van Lierop 1987). Bio-economic models are aimed to investigate changes in environmental resources that have an impact upon socioeconomic systems. Bio-economic models are used to determine the optimal level of resource extraction in function of renewable resources to maximize economic profits (van der Ploeg et al. 1987).

The characterization of bio-economic models may determine their use in environmental modelling research. The bio-economic modelling address economic benefits and costs besides

biophysical values and outcomes linking the feedbacks between economic, social and natural systems. Bio-economic modelling evaluates costs and benefits associated with environmental and natural resource use. Bio-economic models are considered among biophysical and ecological models used to analyze human and socio-economic values to predict economic, environment and human interactions. Biophysical models are considered also bio-economic models including simple economic calculations. The integration of biophysical and economic analyses has a lot of challenges already analyzed by (Bouman, BAM, HGP Jansen, Schipper, Nieuwenhuyse, Hengsdijk & Bouma 1999, Ewert et al. 2009, Kragt 2012, Nunes and van den Bergh 2001, Spangenberg and Settele 2010, Wam 2010).

Bio-economic modelling is considered as a framework to integrate environmental management resources that provide nonmarket values that may be estimated in terms of money as a value indicator (Hanley and Barbier 2009). A bio-economic model to estimate the net present value (NPV) is used by Moore (2008) to manage invasive species.

Bio-economics modelling contributes to an integrated environmental modelling and decisions. Bio-economic modelling has anthropocentric and normative economics basis aimed to allocate environmental resources that yield the highest net benefit to human beings and to value the impacts on human welfare. Bio-economic modeling focuses on the analysis of a set of indicators related to the actions of human beings in ecosystems for production and consumption. Also, bio-economic modeling incorporates the dynamics of ecological complexities.

Bio-economic modelling describes models that have both economic and biophysical components. Bio-economic models integrate economic and biophysical analyses aimed to maximize resource production of forestry, fishery, agro-economic subject to environmental and natural. economic and human constraints.

Spatial bio-economic analysis considers multiple externalities for the spatial management as when Sanchirico (2004) finds the optimal solution of stock, space, and habitat externalities in multiple marine reserves. Blue economy provides biomass from oceans. The spatial bio-economics analyze human-natural ecosystems of natural resources characterized by human, economic, natural and ecological patterns and estimate the cost / benefit solution. Thus, spatial bio economics can support a modeling approach of efficient decision making mechanisms. The managerial control of spatial bio-economic models is related with restoration, development, harvest of habitats in any location and the dispersal and diffusion of species across the space.

Spatial bio-economic models are developed for analyzing the spread of a pathogen across meta-populations. Deconstruction of spatial-bio-economic models (Smith, Sanchirico, and Wilen

2009) is being developed by net growth over time and biomass across space, space boundaries and geometry and net benefits from harvesting renewable resources. More recently, Kroetz and Sanchirico (2015) developed a metapopulational model to relate findings in the spatial bio-economic literature to the public economics theory.

Bio-economic models focus on environmental goods and services, but don't always incorporate intangible ecosystem goods and services (Turner and Daily 2008). The focus of bio-economic models is on economic impacts, although the description is very limited regarding the environmental systems considered as 'irreducible complexity of ecosystem functioning' (Wam 2010) which presents a restriction to the advancement in bio-economic modelling.

Bio-economic farm modelling may consider to integrate analyses of environmental impacts with multiple values that affects agricultural systems (Zander and Kächele 1999). Bio-economic modelling of agricultural systems is characterized by accounting, mathematical programming and regression approaches (Weersink et al. 2002).

Newbold & Eadie (2004) developed a bio-economic model of maximizing total breeding mallard abundance by choosing to restore limited total hectares of wetland sites. Bio-economic valuation model for wetlands management affecting natural resources such as native bird and fish populations estimates also non market values of environmental impact (Whitten and Bennett 2005).

Spatial-bio-economic models are used for the economic analysis of marine reserves (Smith and Wilen, 2003, 2004). A spatial bio-economic model deals with the stochastic spread of a marine disease in a patchy environment (Conrad, 2015). Spatial-bio-economic models are in the emerging literature as for example for the calculation of optimal timing, level of renewable resource harvest, location of harvest and with the development of a stochastic model where AVG induces a regime shift along the coastline.

Bio-economic modelling is a tool in managing fisheries for sustainable fisheries management. An equilibrium model based on bio-economic modelling usually used to measure economic performance can determine the yield a fishery harvest (Yoshimoto and Clarke, 1993). Bio-economic fisheries models not always include calculations of non-financial benefits, biodiversity and ecological services (Eggert 1998). Bio-economic models of fisheries use biological growth functions to calculate changes in the level of fish biomass in function of harvest (Perman et al. 1999). Bio-economic fisheries models calculate environmental factors limited by constant parameters (Knowler 2002). As an example integrated bio-economic valuation studies, Massey et al. (2006) modeled a dynamic approach for flounder fisheries, fish reproduction, water quality conditions, harvest levels, etc.

Bio-economic modelling can determine optimal allocation of fishery management resources. Macher & Boncoeur (2010) developed a bio-economic model to harvest a commercial stock of the French fishery of the Bay of Biscay. Bio-economic theory in fisheries combines dynamic economic and biological factors to provide a framework for management (Larkin, Alvarez, Sylvia and Harte, 2011). A spatial bio-economic model using a stochastic approach to analyze preemptive stock reductions of fisheries influences by factors such as the harvest cost function, lower biological productivity, etc., (Conrad, 2015).

Bio-economic valuation models are based on economic cost-benefit analyses and nonmarket environmental values for different environmental systems. Bio-economic valuation models incorporate market and nonmarket environmental values to assess the impacts of environmental changes and constraints on human welfare. Bio-economic valuation models are criticized by the lack of scientific foundation and collaboration with biophysical modelers (Brookshire et al. 2007).

A bio-economic process based biophysical model to assess the net present value (NPV) was developed by Kragt et al. (2011) to manage changes of catchment hydrology and ecological impacts threatened species, vegetation and seagrass. The Faustmann-Pressler-Ohlin model is an example of bio-economic modelling of forests using a value growth equation to calculate the optimal rotation age maximizing net present value of timber production (Perman et al. 1999). Forestry bio-economic models may calculate no timber benefits (Touza et al. 2008)-

Concluding remarks

Bio-economy is creating a transition from a fossil economy to the new era of economic development. The sustainable use of biomass materials and its optimization are the base of bio-economy affecting a sustainable transition. Bio-economy is driven by the challenges of the natural fossil economy. Bio-economy projects ensure sustainable use of natural resources, values and economic activities. Sustainable bio-economy needs raw materials to be transformed into biomass solutions. Wastes and industrial side streams replacing natural biomasses complement raw materials as the base of sustainable bio-economy and reduces environmental loading. Developing bio-economy promotes the sustainable use residues and waste materials to maximize value. Sustainable land management and biodiversity are integrated with soil and water conservation. Bio-economy growth has an impact on urban planning and land use on planning development.

Sustainable bio-economy has environmental benefits represented by environmental assets and wealth, environmental and resources efficiency, raw material inputs used and the greenhouse gas emissions reduction. Resource-efficient sustainable bio-economy contributes to self-sufficiency in food, health, energy, environmental and natural services. Steering instruments such as the institutional and policy frameworks, as well as the legislation are necessary to ensure an investment environment to ensure sustainability and promote a high added value bio-economy. Natural resources and natural values in ecosystems services contribute to create bio-economy business. Increasing the demand for bio-economy services to provide well-being sustained on the immaterial value creation and nature, is a source of business.

The sustainable bio-economy may generate a nature´s ecosystems with economic growth, bio-economy business, employment, competitiveness, high added value products and services, well-being and boosts the welfare. For this reason, it is important to generate scenarios in which local interests are recognized and to discuss the compensation of economic growth in these areas, equity in the distribution of wealth, sustainability of natural resources and promotion of citizenship participation. This perspective must consider the synergies promoted from the local level that could increase the collective capacity to carry out common actions based on the same interpretation of reality and its possibilities of change.

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