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Extended position paper - Bioeconomy

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Position paper

extended version

Introduction

INRA and Irstea have hosted a european workshop on Bioeconomy on June 28 and 29th, 2017 in Paris. The large audience participation gathered participants coming from European countries (AT, BE, DL, FIN, FR, IT, IRL, LTU, NL, SP, UK) and also Burkina Faso , Canada, Gambia, Georgia, Guinea, Morocco, Russia, USA, Colombia.

A total of 320 people, including a wide range of stakeholders (from research to economic spheres) and disciplines (for research), attended the 28 presentations and 3 roundtables that took place over two days. A youth panel was associated all along the meeting. The knowledges gained during these two days give an ideal opportunity to publish a position paper to provide new ideas and research directions to stimulate further advancement of Bioeconomy. This position paper aims at mapping bioeconomy related issues : R&D related recommendations have been identified. The need for new tools and partnerships and the necessary involvement of new stakeholders were also highlighted. All issues have been classified in four chapters:

- Overcoming disciplinary silos and building a system approach beyond sectors
- Accompanying players on the paths of transition
- Identification of the relevant territorial scales for organizing value creation.
- Measuring, analyzing and improving the implementation of the bioeconomy

- **_Context**

Bioeconomy is on the agenda of many research policies all over the world. National and European strategies share the same definition of bioeconomy.

The Global Bioeconomy Summit (Berlin, 2015) stated that there is a common understanding of “bioeconomy as the knowledge-based production and utilisation of biological resources, innovative biological processes and principles to sustainably provide goods and services across all economic sectors”. The perimeter of the bioeconomy starts from locally available biological resources (forestry and agricultural crops, wastes) and extends to the biological utilization of CO₂ (e.g., concentrated sources of CO₂). Foods, bioenergies, biobased chemicals and materials purposes are considered simultaneously as drivers of bioeconomy.

This approach of development represents a turning point where all three pillars of sustainability are the watchwords. Bioeconomy responds to the achievement of some UN Sustainable Development Goals (SDG), Goal 2 "Zero Hunger" , Goal 7« Affordable Energy », Goal 12 « Responsible consumption and production », Goal 14 « Life below water », Goal 15 « Life on Earth » and the terms and ambitions of the Paris Climate Change Agreement.

Bioeconomy is no longer another issue but a paradigm change for sustainable development. An old sociotechnical system is dying away, while a new one struggles to come forth. Since the first use of the concept of bioeconomy in 2005-2010, its content has evolved and new issues are now on the top of the research agenda.

- **_Statement of the position**

The bioeconomy is above all a political vision emblematic of the **ecological transition** Its development requires breaking with the old linear logic of separate optimization in the different production and transformation sectors, and to "think system" instead. **Bioeconomy is enrolled in three major directions:** (a) valorization of the traditional sectors linked to agriculture, forestry and fishery complemented by the wastes, (b) high-tech innovation mainly based upon biotechnologies, and finally (c) changes in demand, favouring consumption of sustainable goods and reduction of waste and fatal losses. Beyond linear « cause and effect » relationships, non linear relationships (coupling, retroaction, cascade, snowball effects) arise from interrelationships among various parts, either environmental, social or technical factors affecting the organizational performance. The corollary is that optimization of each pillar alone (environment, economical, social) tends to increase undesigned relationships, injurious to the system's performance. The consequence is the need to develop joint optimization or ecodesign, that is, designing the environmental, social and technical system so that elements work smoothly together, inside a system boundaries. Relationships between the three pillars lead to productivity and wellbeing simultaneously, rather than the all too often case of new technology failing to meet the expectations of designers and users alike.

The bioeconomy is partially (*but not completely*) inscribed in the circular economy, this later encompassing other sectors. Two new concepts enrich the landscape: cascading uses, and closing of C, N, P and K cycles. These concepts challenge the notion of a null or even negative value of waste in the value chains and, as a consequence, the link between the

material specifications of products entering or exiting successive operations. In this way, the bioeconomy makes possible to decouple growth from the use of raw materials. A major question still remains about phosphates that are non-renewable since they are mined, requiring a 'recycling' perspective as well.

The bioeconomy has not yet given rise to a **collective policy construction involving all of the actors of society**. Such a construction should be based on a line of thought targeted at the young generations who will be the actors in 2030-2050, by focusing on "environment-diet-consumption-health-life" nexus. How can we articulate collective goals whose formulation is delicate, actors whose status and interests are very different, heterogeneous territories and variable time scales? It assumes a re-assessment of the relationships between the different stakeholders from the agricultural community, up to industries and managers of end-of-life products. A shared systemic framework, with emphasis on desired use functions should determine degrees of freedom, consequently revealing links and material savings between sectors. Policy-makers, private sector, civil society, foresight and think tank oriented activities are welcome in these discussions, prior to the definition of public policies based on principles of transparency, openness and evidence.

The bioeconomy must therefore rely on a real **research strategy**. Even if this notion of the bioeconomy is already present in several sections of different national research strategies, it mainly consists of an evocation of societal challenges and areas of science without extending to new research questions. Basic research remains the cornerstone of science-based development and science-based policy. At the same time, more systematic networking, interaction and collaboration between scientists and practitioners, and new fundings for that kind of transdisciplinary interplay are needed. We need programmes for "knowledge creation" as well as for deployment addressing the value chain approach (e.g. PPP) as both of them are equally important. The industry-driven bottom-up instrument like a PPP should foster cooperation between public and private actors, and stimulate investments.

First issue : overcoming disciplinary silos and building a system approach beyond sectors

Several **scenario-based foresight** studies are in progress or have already been published, all considering sectors, energy or foods individually. Major efforts are necessary to discern possible evolution pathways of biomass uses based on supply or demand from different angles in the planet boundaries, able to consider the impacts of breakthrough developments in certain sectors on other sectors of the bioeconomy.

The bioeconomy requires scenarios with a **long time horizon (2050)** to represent contrasting situations and to simulate evolutions that will help us to prioritize research issues. These **scenarios should integrate the drivers** (foods, bioenergies, biobased chemicals and materials) **in order to verify the comparative interest of contrasted options and their compatibility, in particular, and to shed light on the choice of future investments.**

The major problem is the current lack of integration between the different activities, whether it be the species-variety-cropping system shift or the integration of crop production and initial transformation. A generic tool to develop scenarios and to model systems at the regional scale, to create scenarios for the development/destruction of activities (because it will occur) and to reflect on training and education is also lacking.

In these scenarios, it would be necessary to summarize the underlying hypotheses, lock-ins, whether they are explicit or not, and to undertake a survey of the scenarios and models that are currently used or proposed (or, if this is not possible, to propose a "bioeconomy" framework within which the models and scenarios could be analyzed by crossing vertical and horizontal fluxes). This would make it possible to identify convergences, contradictions, overlapping of scales and possible links within a bioeconomic perspective ranging from the impact of humans on ecosystems to public policies, and including the biotechnologies, processes, organizations, jobs, environmental externalities, etc.

Whatever the intensity of bioeconomy development, biological resources, including soils, should not be depleted by overconsumption to guarantee the ability of future generations to meet their own needs. The opportunities and risks of bioeconomy development with a view to sustainability have to be defined in the broad frame of the diversity in bioeconomy strategies. This threshold of overconsumption should lead to the definition of **bioresource belts**, adapted to each long term and integrated strategy.

Within the overall bioeconomic system, the **worldwide generalization of the Western food model is not possible** without endangering the ecosystems themselves. The determinism of contrasted evolutions of diets observed worldwide requires dedicated research that combines nutritional and cultural components, as well as an analysis of generational evolutions (the impact of long-term flexitarian/vegetarian behavior). This "consumption of animal products" variable must be combined with demographic evolutions, along with the major uncertainties concerning their quantitative predictions. Qualitatively, trends in aging and urbanization are significant and will have a strong influence on consumption patterns and the consumption of space. The first lever to reduce our diet's environmental impact is to waste less, and eat just what we need. More research is needed on **policy and societal relevant research which gives insight how to steer the food sectors in more sustainable, healthier and more equitable way** .

Food security is considered as a priority (*Food first*). Up to now, the global food security debate has a single dominant focus: increasing agricultural production to gain both **physical access** to food and adequacy with **purchasing power**. At local scale, this productionist bias has to be revisited with agroecology-push. Meanwhile it is a question of proposing a food supply that meets the needs of consumers (sanitary, nutritional, hedonistic, cultural, ethical ...), accessible to all and favorable to well-being, health and the environment. The cross-sectoral and / or systemic approaches specific to the challenges of the bioeconomy fall in the system approaches. Meat and milk products certainly constitute one of the adjustment variables at the world scale, but little explored until now: what are the scenarios for an eventual decrease in Europe of milk and meat products from 10 to 20% over 30 years, and what would be the impacts on the availability of biomasses and farmland ? Adequate public policies should play a major role for orientating production systems to sustainable solutions. **Re-evaluating food sectors in view of a bioeconomic system** raises the issue of trade-off between environmentally cropping and livestock systems driven by agroecology and food supply that meets the needs of consumers (sanitary, nutritional, hedonistic, cultural, ethical ...), accessible to all and favorable to well-being, health and the environment.

The design of **sustainable cropping systems** under constraint of uses of the biomass produced leads to the diversification of crops and of the competitiveness of « minor » crops, as well as the development of varietal innovation on defined traits for the suitability for use, processing processes and the sustainability of production systems. More diversified cropping systems at the field, farm and territory levels mean changes in the storage capacities and first transformation steps. Digital technologies should bring decision support systems for better agricultural production, ie producing more while impacting less on the environmental, whatever the type of agriculture. Digital bioeconomy is not a magic wand. More research is needed to develop hard and softwares suited to system and subsystems.

The stacking of public policies that oppose or ignore food and non-food end-purposes, or production vs. transformation, constitutes a major difficulty to overcome to ensure greater coherence and efficiency in the EU's actions.

At least six public policies are concerned with bioeconomy :

- Food, nutrition and health policies ,
- Climate, energy and environmental policies,
- Agricultural and fisheries policies (CAP),
- Integrated Maritime Policy (IMP),
- Trade policies,
- Rural and urban policies.

This segmented approach overlooks activities that already exist (local industrial ecology where food, chemical and energy uses of the biomass are considered together in economic and technological models), impeding the revision of generic economic model and neglecting the role of small and medium-sized companies in the establishment of an industrial sector. Agricultural cooperatives, some of which combine production and initial processing, play an important role by occupying the first level of the biorefinery. However, the identification of specific researches dedicated to the bioeconomy is still to be done, with the danger of exclusively relying on sector policies disconnected from the necessary systemic vision. **More multidisplinary research is needed to help to analyse cobenefits and trade-offs in bioeconomy.** The diversity of territorial authorities and the variability of the perimeters of management of public issues clearly raise the question of the institutional arrangements determining the framework for the exercise of political power and the modalities of cooperation between the actors.

A Bioeconomy panel or Council could foster strategic dialogue with policy-makers, private sector, civil society and scientists, based upon foresight basis. It **should be involved in the analysis of these policies with the aim to select Evidence-Based Policies and to monitor progress** at an international level.

Second issue : accompanying players on the paths of transition

Starting from our actual productive systems, one difficulty is to insert bioeconomy in the dynamics of ecological transition. In fact, characteristic time responses for technological segments of the system cover a wide time range, from the instantaneous act of consumption, the hours and weeks of transformation, up to decades of forest production. Finally, the development of indicators linking agricultural and forestry practices to products resulting from the bioeconomic system assumes that links within the sector or between

different sectors (e.g., between milk and meat) are taken into account by proposing robust distribution criteria.

Re-evaluating technological leverages in view of a bioeconomic system raises four questions:

- production and transformation processes are not linearly extrapolable and make us question change of scale laws. At this stage, we do not yet know if the bioeconomy will be an exception to the scale economy law. This response will affect the re-evaluation of traditional processes (downsizing, upscaling) using current ecodesign tools.
- usage functions (clothing, bioenergies, hygiene, housing) can be partly fulfilled by "bioeconomic" processes and products without necessarily using current molecule platforms derived from fossil fuels. Two pathways are possible: a progressive evolution through isomolecular substitution or an isofunctional rupture.
- the link to be created with agronomy in view of the rise in agroecology. How can the bioeconomy generate constraints vs. new opportunities for agriculture (economic diversification: evolution of farming systems with land use, cropping systems with the choice of species) and, more generally, the development of ecosystems ? Does reflection at a regional scale make it possible to identify new possibilities for designing and optimizing a system that works or does it create more constraints and, overall, a drop in efficiency? A topic thus emerges at the intersection of agroecology and biorefinery.
- intra/inter synergies between production areas by exploring space and time scales. Fulfilling several elementary human needs will raise the question of how to ensure long-term supply, resulting in an assessment of the **resilience of systems facing climate hazards**.

Without innovation and (global) innovation management, the bioeconomy cannot become sustainable/effective for the planet. Modern biotechnologies are game changer essential to the bioeconomy. Starting from exploration and characterization of continental and marine biodiversity, including microbial consortia, green and white biotechnologies have already clearly revealed the contributions of incremental innovation and the disruption of production (photosynthesis) and processing systems, and remain the major hope for new technological innovations, with, in perspective, synthetic biology coupled with systems biology. In some way bioeconomy considers biomass and related processed at the molecular level, reinforcing the opportunities of predictive approaches in modern biology (-omics) and quantitative structure-property relationships.

Besides mass and energy considerations, production and transformation throughout the processes generates data, hence a link with *big data*, even if *low data* is not to be overlooked. Its structure and composition linked to the context create different situations (in contrast to gasoline that is more homogeneous) that must be taken into account in order to corroborate sustainability and to design *in silico* experiments to test a diversity of possible situations in terms of biomass and processes or combinations of processes.

Innovation projects need to cover the entire value chains. These prospects for innovation require the availability of infrastructures to ensure advances in technological maturity. The advancement of any project would necessitate the mobilization and synchronization of the engineering disciplines, social science. The link between bioeconomy and agroecology raises the question of systemic experiments. The link between varietal innovation and the optimization of cropping systems is an element of rupture to be integrated into

experimental setups to corroborate synergies between crops and the associated ecosystemic services. A consequence of this is to design long-term projects that include Go/NoGo steps.

Committing to the transition (and accelerating it) requires clear, coherent, consistent and persistent signals:

- Changing the system of relative prices for products by creating value through the internalization of the cost of damage to the environment (water, biodiversity, climate change, health) or of the value of ecosystemic services rendered, via incentives (taxes or permit markets) or normative systems.
- Including the entire life cycle in the price .
- Redistributing this value creation at the core of loops that are virtuous because of their incentive potential, thus encouraging the convergence towards new standards of production and consumption.
- Stabilization of the different public policies over long periods of time to allow for the investment and, therefore, the commitment of private stakeholders, NGOs, cultural front runners (bloggers, vloggers) and companies.

Third issue : identification of the relevant territorial scales for organizing value creation.

All strategies point out the need and the objective to **more effectively allocate the resources inherent** (natural and regional, human, scientific) to each country or region. National specificities are linked to local pedoclimatic, topographic features and land ownerships. So the rule *One size fits all* does not apply to bioeconomy. The interface between production and transformation occurs at the biorefinery stage ; bioresource processing processes (chemical, physicochemical, thermal, pre-treatment, separation, purification, etc.) allow multiple valuations and adaptation to biomass heterogeneity (variability, volumes, specifications, prices, etc.).

Forestry represents a major element of bioeconomy. Important regional differences of the forest-based sector in Europe are due to the different forest ecosystems, popular representations, infrastructure and various forest ownership structures. The rule of local differences applies also to **mediterranean regions comparatively to Northern EU regions**. This concerns in particular 3.5 billion of ha of mediterranean area abandoned land which could be valorized to grow autochthonous, and resilient food or industrial biomass, provide value to the abundant vegetation and products of local forestry and the large volumes of agri-food by-products and waste for the mediterranean food/biobased industry.

Different levels of organization and spatial and temporal scales are concerned:

- spatial scale, from the gene to the individual, from the individual to the cropping and livestock subsystems, and then to the ecosystem; At the same time, mass exchanges between rural and urban areas have to be mastered in the framework of circular economy.
- temporal scale, from short-term decisions (financial) to long-term goals.

Research must also focus on the articulation between these scales, from local solutions to global coordination. A **mapping of sustainable regional biomass potentials** is key to estimate potential development and reorganizations between sectors that rely on biomass

resources. Together with projections on the biomass demand from foods, bioenergies, biobased chemicals and materials, it is possible to identify the most promising biomass resources, cascade uses and value chains for their utilisation. These complex and interrelated domains mobilize the life sciences, soil sciences and agronomy, human and social sciences and materials sciences for the transformation of bioresources.

Depending on the local availability of biological resources and/or wastes, it is possible to initiate projects that depend on the opportunities provided in a country to develop pilot facilities. More generally, the issues developed initially with food can be extended to bioenergies and biobased chemicals and materials. They concern in particular:

- socio-technical configurations of sectors: the capacity of sectors to integrate new constraints and to generate productivity gains; Dynamics and territorial organization of food systems; Distribution of value between actors in the sectors; Resilience to economic or health shocks; Challenges of competition and complementarity between food industries, agro-industries and retailing;

- Public policy design and performance: impact analysis and levers of action for public policies targeting system actors (companies, consumers, new actors, etc.).

The key factor for transition is the move from « niche » in the former productionist regime « under tension » to a new one by percolation of the sociotechnical system of the niche, establishing thereby a new regime.

Experiments where the behavior of citizen-consumers-households is considered, could be implemented within this framework. This behaviour is a variable in interaction with other variables (type and availability of consumer goods, organization of space, public policies, etc.). This goal **requires living labs that will also make it possible to observe *in vivo* the coherence of technological and organizational innovations**, to co-design and co-learn in these innovation platforms.

Emerging science can bring major opportunities. However in developing countries, the promise of bioeconomy is first on better using the biomass resources, which they have, and also from circular thinking and different ways of using the resources ('value add'), taking advantage of knowledge that is already available and still underutilized. The problem of the fair distribution and dissemination of new knowledge and technologies across the globe is quite crucial.

Fourth issue : measuring, analyzing and improving the implementation of the bioeconomy

The bioeconomy is not intrinsically sustainable. Furthermore , another difficulty is to agree on what we can consider sustainable: the different countries of the world and of Europe do not share the same vision

The **main challenge here is to corroborate sustainability**, which requires a clarification of the importance that we give to **negative externalities**. The first difficulty is to more effectively take account of the diversity of the different scenarios in life cycle analyses (LCA) by considering local conditions (water, pollution, etc.) and the necessity of being able to compare very different human activity systems without making an exception for anteriority. Social LCA is the less developed pillar and deserves more research.

The aim here is to develop research on:

- improved assessment, decision support and monitoring tools for the environmental, economic and social performance of the bioeconomy, particularly in cascade applications (LCA, risk and uncertainty assessment, industrial ecology, Taking account of direct and indirect changes in land use, etc.);
- methodologies (and their softwares) for assessing the social, economic and environmental performance of models for the bioeconomy including transition processes, valid for any scale of assessment;
- methodologies for assessing social changes due to diffusion of digital technologies which changes social organisations,
- measuring the impact of the energy transition on productivity,
- measuring the anthropogenic pressure expressed in terms of entropy, using criteria such as HANPP (Human Appropriation of Natural Primary Production).

In light of these results, coherent regional bioeconomy policies will be written according to a defined hierarchy of impacts (upon health).

As bioeconomy is linked to public goods, **sharing open data** is a key point to ensure citizens' acceptance. The availability of datasets concerning environmental, economic and social impacts is crucial in order to eliminate ambiguities about new solutions and to adopt cost-benefit approaches, systematically taking the *business as usual* option into consideration.

Before implementation, regulatory issues concerning new technologies have to be considered. It raises the question of whether new ways of public engagement are needed. The key is to foster strategic dialogue with policy-makers, private sector, civil society and scientists, including foresight and think tank oriented activities.

Finally these suggestions fit with an **International R&D network**, to explore opportunities for long-term international research and development collaboration on these cutting-edge sciences. For example, a network of centers on LCA could facilitate exchange of practices, each given locus considering specific impacts and/or specific sociotechnical systems.

An overall consequence of these four chapters is the need to **develop training programs**, both in terms of their content and their methods for managers capable of mastering data, modeling and making decisions based on multicriteria. Design becomes also a key expected skill, because the best bioeconomy system does not exist by itself. Training "to and by a systemic vision" is indispensable and must include systemic research projects that are, above all, platforms for co-construction between training and research, in order to go beyond the call for interdisciplinarity alone. Team working is more important as it already was. This results in the need to develop a community/network (and to mobilize platforms) for multiscale and transdisciplinary systemic modeling and design.

Presentations and additional informations are available in the workshop website:
<https://colloque.inra.fr/bioeconomy2017/>



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