Dr. Neus Escobar and Jan Janosch Förster
Center for Development Studies (ZEF), University of Bonn

GOVERNING TOWARDS A SUSTAINABLE BIOECONOMY: A CONCEPTUAL FRAMEWORK FOR LIFE CYCLE GOVERNANCE ANALYSIS

1. Introduction

An economy based on the sustainable use of renewable biological resources is often proposed as a viable strategy to reduce fossil resource dependency and to meet global sustainable development goals, i.e. by transitioning to renewable feedstock for material and energy production in a variety of sectors. Technological innovations, social and political advancements, and consumer behaviours are crucial factors for initiating, steering and adjusting transitional pathways towards a sustainable Bioeconomy. Institutional and regulatory frameworks, as well as policy and legal structures, are necessary when establishing emerging bio-based supply chains for further environmental and social achievements, in addition to economic ones. This will involve a large number of actors, from almost every level of biomass production, extraction, processing and manufacturing. Hence, in order to enhance coordination among them towards common goals and avoid spill over effects, sustainability interventions must be adopted with the entire supply chain in mind.

Producer efforts have focused mainly in reducing feedstock costs in order to be competitive relative to the fossil-based counterpart. This can increase environmental and social pressures associated with monoculture, either domestically or internationally. Furthermore, globalisation of production and trade also influence industrial organisation beyond consumers'' preferences (Gereffi et al. 2005). With bio-based supply chains being trans-national, there is the risk for the least developed economies to become net biomass exporters while more developed countries concentrate transformative power in the industry. Besides inequality, this is likely to intensify competition for land between food-energy-material uses, pushing impacts further down the supply chain; hence the need for effective governance schemes that take the diversity of supply chain configurations into account. In the specific case of biomaterials, potential societal benefits may arise in end-of-life stages through biodegradation. Therefore, regulations on recycling and disposal should be equally considered when conducting a comprehensive analysis of mechanisms influencing the viability and sustainability of new products in the Bioeconomy.

Governance can be understood as the coordination of societal action (Benz et al. 2007). As such, we assert that governance means -to a certain degree- shape and guide social and economic action through the existence, but even more important the enforcement of legal prescriptions stemming from national law and other binding regulations by state authorities or international regulative agents. With regards to the Bioeconomy, this is rather focused on socio-economic action. Governance means can be legal, administrative, economic, financial, social, political regulations, processes, norms, institutions and organisations created through social action. In everyday realities of governing a process, combinations of these means are found and governance rarely touch upon only one field of policy, but rather on multiple fields on various societal levels, involving multiple actors.

Supply chains are complex systems with different structures and power proportions between partners; governance of companies' interactions is necessary (Crisan 2012). Studies have been conducted in the fields of supply chain management, supply chain governance, corporate and network governance, etc., as tools to inform behaviours and decisions of procurement within an organisation via legislative, executive and judicial processes with the ultimate aim of enhancing economic performance. On the other hand, actions of firms that contribute to social welfare, beyond what is required for profit maximization, are classified as Corporate Social Responsibility (McWilliams 2000). However, an analytical framework able to capture multiple levels of governance structures on multiple levels of socio-economic organisation concerned in developing bio-based transformation pathways is, however, lacking. In this paper we present a theory-informed methodological approach that goes beyond the too often firm-centred organizational and institutional approaches, by also addressing the influence of local, regional and international factors in a telecoupled world.

2. Life Cycle Thinking

In order to address sustainability implications of production systems from a rather technological perspective, Life Cycle Thinking (LCT) proposes going beyond the narrow traditional focus on production sites and manufacturing processes, and incorporate the environmental, social, and economic impacts of a product over its entire life cycle (UNEP-SETAC 2012). To this aim, different methodologies have been proposed under the umbrella of Life Cycle Sustainability Assessment (LCSA) (UNEP-SETAC, 2011); namely Life Cycle Assessment (LCA), Social LCA (SLCA) and Life Cycle Costing (LCC). Although there are notable differences among them, their common feature is that they address environmental, socio-economic, and economic impacts, respectively, from the “cradle to grave”, i.e. encompassing all processes between production and disposal. Of the different methodologies, the LCA is considered the most developed, and is widely applied to better inform process optimization and eco-design. UNEP-SETAC (2009) attempted to create a standardized procedure for SLCA in order inform social performances of socio-economic aspects, despite the qualitative nature of issues such as human rights, health or safety. All of these approaches are process-centred approaches, which consider systems in isolation, usually missing the business and market perspectives. Life Cycle Management (LCM) and Organizational LCA (OLCA) (UNEP-SETAC 2007; UNEP-SETAC 2015) address these issues by broadening the integration of LCT on a “top to bottom” basis. Both tools can serve to improve product systems and support assimilation of policies in line with sustainable consumption and production patterns, while enhancing collaboration and communication to all stakeholders in its value chain.

Although these methodologies try to accommodate knowledge from different academic disciplines to provide more expedient answers to address sustainability questions, political approaches are rarely involved and the influence of governance in supply chain decisions remains unexplored. Only SLCA proposes “governance” as an impact category linked to “value chain actors” (UNEP-SETAC 2009). However, we argue that the political and social dimensions should be considered separately. Hence, we propose a framework for Life Cycle Governance Analysis (LCGA) to compliment and operate in parallel to the three aforementioned approaches for LCSA. In the following ‘the A’ in LCSA stands for ‘analysis’, which is conceptually and methodologically more refined than “assessment”. Figure 1 shows where our proposed framework could fit (to fill a governance gap) in the picture of life cycle methodologies.

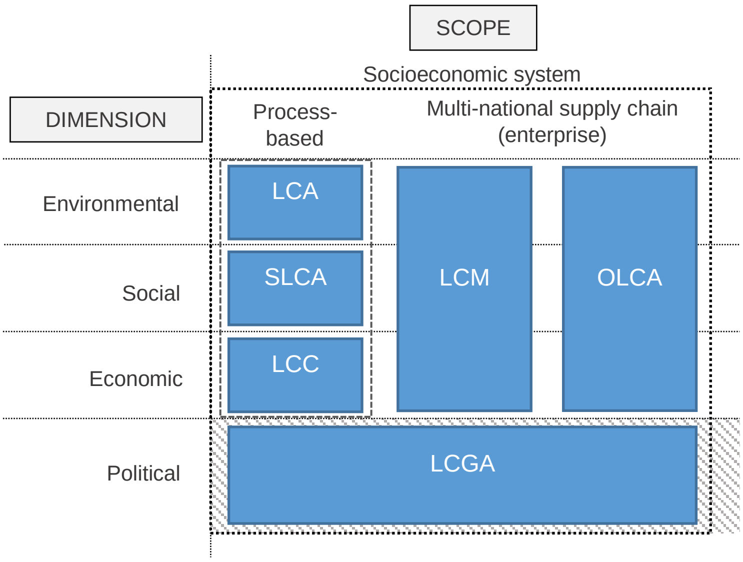

Figure 1. Theoretical background for the development of life cycle methodologies covering different dimensions for the holistic assessment of sustainability.

Our framework for LCGA addresses the political aspect as a separate dimension covering production decisions along the whole socioeconomic system. LCGA expands the scope of the typically process based LCA from micro-level, to also include meso-macro levels of analysis, necessary for the understanding of global supply chains. For instance, SLCA also takes into account global regulations as thresholds for sustainability compliance. It must be noted that “supply chain” is not exactly a synonym of “life cycle”; the latter considers not only suppliers of raw materials, hereinafter called the “foreground system”, but also suppliers of inputs, e.g. energy, hereinafter called “background system”. The background system also includes secondary products delivered throughout the life cycle. In this way, governance can be understood as a superior system for product management (Crisan 2012). For the LCA community, this can contribute to the ongoing methodological debate on SLCA (Dreyer et al. 2006).

LCGA consists of adopting multi-level governance approaches from a life cycle perspective, in order to enhance coordination among supply chain actors, beyond organizational boundaries at local, regional, and international levels. LCGA aims to: a) characterize main policy and legal structures, as well as public and private actors involved in governing bio-based supply-chains in specific contexts; b) identify regulatory challenges and gaps that can arise from scaling up specific technologies; and c) supporting policy development, formulation and implementation for the organisation of value chains in order to minimize unintended social and environmental outcomes. It is specifically developed for emerging supply chains in the Bioeconomy, since most investors are not familiar with specific regulations (e.g. intellectual property rights in the biopharma industry) and there are legal gaps. At the same time, this helps to narrow the scope of analysis to facilitate further theoretical development.

3. Framework for Life Cycle Governance Analysis (LCGA)

The conceptual framework we derive by integrating life cycle and multi-level governance approaches. It consists of three phases, by following the standardized LCA procedure (ISO 2006), namely: a) goal and scope, specifying the supply chain configuration and system boundaries; b) life cycle inventory (LCI) of stakeholders and institutions within the system boundaries at the institutional, regional, and international levels (multi-level analysis); c) impact analysis to evaluate the effects of changes in the governance of supply chains on production patterns from a multi-sector perspective. These phases are further explained below.

3.1. Goal and scope

This phase consists of defining the motivation for the LCGA, based on the historical context, socio-economic patterns, market projections, and technological and environmental constraints. Secondly, limiting the scope of analysis by indicating the specific geographical area and time horizon in which the selected life cycle is supposed to operate. This specification is crucial given the diversity of laws and regulations in time and space, especially in the very dynamic sectors found in the Bioeconomy, which require regulations that are in tune with societal aspirations.

A critical aspect of the procedure entails the definition of the system boundaries, i.e. indicating the sub-processes included in the system under study. This entails the necessary interlinkage of conceptual sub-steps involved in governance. We draw upon social theory and theoretical governance thinking to identify three main categories that must be also distinguished, namely *structure*, *agency* and *context*. Structures comprise all institutions of the state (legislation, judicial decisions, government bodies such as ministries, administrative bodies, enforcement authorities and bodies with a control and oversight function. From a multi-level governance perspective, this includes supra- or international bodies instated by an act of governmental authorities entering a binding legal agreement with the power to issue regulations. Agents are all other actors, entailing private companies and actors of civil society, with the resources and capabilities to act in one or more sequential steps of the supply chain. Context refers to the circumstances in which something is happening, which provide causal analytical value to the aspect under study. As especially relevant for the Bioeconomy this comprises the biophysical environment of natural resources endowments, but also other potentially relevant aspects with explanatory value for assessing governance gaps, such as historical factors. Figure 2 describes the multi-layer governance-related aspects that should be taken into account within the system boundaries when performing a potential LCGA.

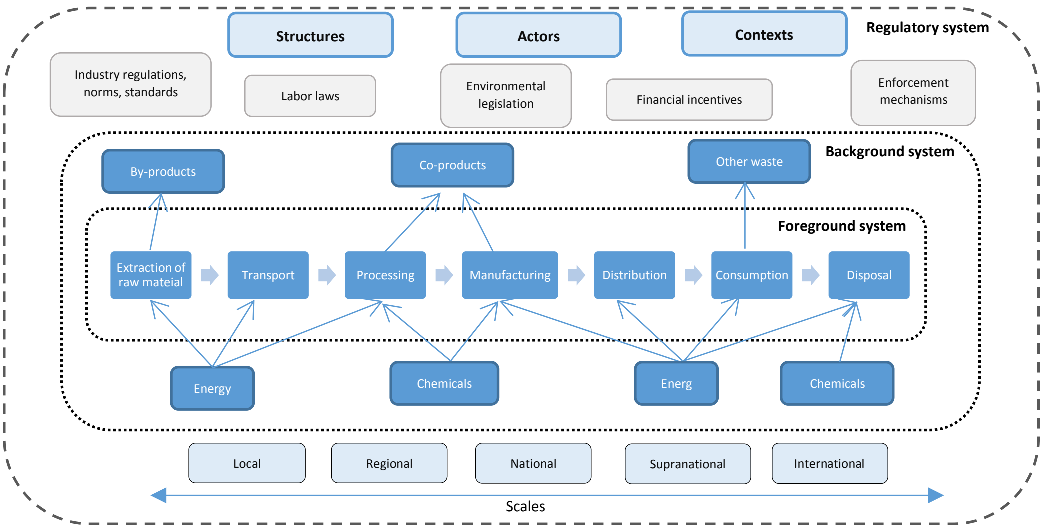

Figure 2. System boundaries in LCGA.

In view of the complexity of the political system, it is necessary to identify specific cut-off criteria at this stage, depending on data availability and/or the relevance of the sub-stage in the supply chain. Cut-off criteria must be specified; this may lead to excluding the background system from the system boundaries; also consumption and disposal stages, as often happens in LCAs, as these involves many agents (e.g. households). It can be expected that gathering data for the foreground system will be easier (at the company level), while upstream and downstream sub-stages will require relying on global and institutional data at the macro-level. Given the qualitative nature of the LCI, there is no need to define a Functional Unit as a reference flow; the function of the system must be, however, made explicit (e.g. producing Polylactic Acid in Thailand from domestic sugarcane in a given year).

3.2. Life Cycle Inventory (LCI)

The LCI entails identifying all the stakeholders and institutions involved in governing a specific life cycle (i.e. supply chain, if the background system is excluded), at local, regional, national and international levels. This provides, for each case, a roadmap of socio-economic actions and socio-political accounts at the local, regional, national and international scales, corresponding to the interplay of structures and agents within specific contexts. This is the most time-consuming stage since it involves relying on reports and information at the micro-, meso- and macro-level. Given the variety of data sources, there is a need for a systematic approach; we define a set of categories for actors and institutions, based on the stakeholder categories proposed for SLCA (UNEP-SETAC, 2009); these are shown in Table 1.

Table 1. Categories of actors, institutions and contexts for a systematic LCI.

Categories	
Institutions	**Actors**
Governments	Entrepreneurs
Administrative bodies	Investors
Enforcement authorities	Traders
Regulative bodies	Suppliers
	Workers
	R+D departments
	Local community
	Society

3.3. Impact analysis

Being at a first development stage, this paper mainly focuses on the first two steps, although the goal is to develop a set of themes to capture governance effectiveness of alternative bio-based pathways based on novel technologies. According to Vanclay (2002), impacts arise from the interwoven concept “effect caused by change within a certain context”. This phase tries to measure the relationship between governance mechanisms and sustainability outcomes. The goal is to provide indicators to evaluate the effects of changes in the governance of supply chains on production patterns (i.e. supply chain configurations) from a multi-sector perspective. In this case, indicators are not a quantifiable representation of an impact category through characterization methods; instead relying on the strength of causal relationships between governance means and production patterns. The link between production patterns and sustainability outcomes is ultimately given by the LCA/SLCA/LCC methodologies.

4. Preliminary conclusions

A framework for LCGA is proposed as incremental procedure for the multi-level assessment of governance risks and gaps in the Bioeconomy. In this way, it can also be applied to the study of increased biomaterial production scenarios, e.g. with bioplastic supply chains becoming transnational or involve global dimensions. Once fully developed, our conceptual framework can contribute to reducing resulting systemic complexities and uncertainties in bio-based transformation pathways providing the conceptual starting points for a regulatory structuring of socio-economic processes and actors along bioeconomic value chains. It aims at increasing transparency in regulations affecting production decisions, in order to identify governance gaps and comparative advantages. Our framework can possibly apply to policy revision and adaptation, i.e. adaptive governance. Although carrying out comprehensive LCGA is not possible yet, our overall goal is to further spark scholarly discussions around governance approaches to foster, but also regulate the Bioeconomy towards more sustainable production pathways.

5. References

Benz, A., Lutz, S., Schimank, U. and G. Simonis (Eds.). 2007. *Handbuch Governance. Theoretische Grundlagen und empirische Anwendungsfelder*. Wiesbaden.

Crisan E. 2012. Supply chain governance and multinational corporations' governance: a theoretical comparison. *Pol J Manag Stud,* 6: 33-44.

Dreyer L., Hauschild M., and Schierbeck J. 2006. A framework for social life cycle impact assessment. *Int J Life Cycle Assess,* 11(2): 88-97.

Gereffi, G., Humphrey, J., and Sturgeon, T. 2005. The governance of global value chains. Rev Int *Politi Econ*, 12(1): 78-104.

ISO (2006). ISO 14040 International Standard. In: Environmental Management. Life Cycle Assessment Principles and Framework. International Organization for Standardization, Geneva (Switzerland).

McWilliams A. 2000. *Corporate social responsibility*. Wiley Encyclopedia of Management.

UNEP-SETAC.2007. Life Cycle Management: a Business Guide to Sustainability. UNEP-SETAC Life Cycle Initiative. Paris (France).

UNEP-SETAC .2009. Guidelines for Social Life Cycle Assessment of products. UNEP-SETAC Life Cycle Initiative, Paris (France).

UNEP-SETAC. 2011. Towards a Life Cycle Sustainability Assessment. Making informed choices on products. UNEP-SETAC Life Cycle Initiative, Paris (France).

UNEP-SETAC. 2012. Greening the Economy Through Life Cycle Thinking: Ten Years of the UNEP/SETAC Life Cycle Initiative, UNEP-SETAC Life Cycle Initiative, Paris (France).

UNEP-SETAC. 2015. Guidance on Organizational Life Cycle Assessment. UNEP-SETAC Life Cycle Initiative, Paris (France). ISBN: 978-92-807-3453-9.

Vanclay, F.2002. Conceptualising social impacts. *Environ Impact Asses*, 22:183–211