Sustainability governance of bioenergy and the broader bioeconomy

Technical Paper prepared for IEA Bioenergy Task 45 and the
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Final draft

prepared by

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Acronyms

BIC	Biobased Industries Consortium
CoC	Chain of custody
EC	European Commission
EU	European Union
EOL	End of Life
ENGOs	Environmental Non-Governmental Organizations
GBEP	Global Bioenergy Partnership
GHG	greenhouse gas(es)
IEA	International Energy Agency
IEA Bio	International Energy Agency Bioenergy Technology Collaboration Program
OECD	Organisation for Economic Co-operation and Development
RED	Renewable Energy Directive
SDG	Sustainable Development Goals
SLO	social license to operate
SSOs	Standard-setting organizations
UN	United Nations
UNFSS	United Nations Forum on Sustainability Standards
VSS	Voluntary Sustainability Standards
WTO	World Trade Organization

Introduction and Overview

The bioeconomy – and bioenergy as part of that – provides key opportunities to achieving the Sustainable Development Goals (SDGs)[1], and to contribute to a "green" recovery after the COVID-19 pandemic[2]. For this, though, it is crucial to assuring sustainability governance of the bioeconomy, e.g., regarding access to land, conservation of biodiversity, mitigating climate change, providing employment, ensuring food security, and water availability.

This paper aims to provide an overview of the status and recent developments of bioenergy and bioeconomy governance for the Sustainability Task of the Global Bioenergy Partnership[3], IEA Bioenergy[4], and the interested public.

In particular, the objectives of this paper include:

- Provide an overview of the status of the bioenergy and bioeconomy particularly in terms of expected demand and respective impacts (Section 1).
- Define what governance is and summarize the status of bioenergy and bioeconomy governance (Section 2)
- Identify promising sustainability governance approaches for the bioeconomy (Section 3).
- Present perspectives on sustainability governance of the bioeconomy (Section 4)

The annexes to this paper provide complementary information on

- bioeconomy strategies (A-1),
- definitions of governance (A-2), and
- bioeconomy governance principles (A-3).

Throughout this report, we refer to bioenergy as part of the broader bioeconomy, similar to food & feed, fisheries, forestry, and waste management being part of the bioeconomy.

Yet, bioenergy is dealt with specifically, as it has a prominent role in the energy system and is already subject to sustainability governance[5].

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1 As agreed upon by the United Nations General Assembly in Sep. 2015 as part of the 2030 Agenda, see https://sdgs.un.org/goals

2 See e.g., Fritsche et al. (2021) for an analysis of possible bioeconomy contributions to the COVID-19 recovery in the European Union.

3 www.globalbioenergy.org

4 https://www.ieabioenergy.com

5 For sustainability governance of agriculture and forestry see Section 2.3.

1. Sustainability of Bioenergy and the broader Bioeconomy

The call for a global transformation towards sustainable development and the respective Sustainable Development Goals (SDGs) were agreed upon in the UN Agenda 2030 in September 2015 (UN 2015). Bioenergy and the broader bioeconomy are considered as means with significant opportunities for a more sustainable use of renewable resources, and for reducing fossil fuel use[6].

Yet, if produced uncontrolled, increased use of biomass for energy and materials, as well as for food & feed, could lead to the over-exploitation of the finite biomass, land, and water resources, and could imply reduction of biodiversity and social impacts related to land and water use (Fritsche & Rösch 2020).

This paper aims at identifying governance approaches allowing to both use biomass sustainably and to safeguard against respective risks. The EU, many OECD countries as well as developing and emerging economies, are promoting bioenergy development, in part to mitigate climate change, to foster rural development, and improve energy security. Several countries and the EU have begun to support the development of the bioeconomy and have started to introduce policies to safeguard against negative environmental impacts (especially regarding climate change) which highly depend on which biomass is used, from where, how and for what purpose.

1.1. Bioenergy

Biomass use for energy increased globally during the last decade (REN21 2020), and the recent World Energy Outlook expects a continuing increase (IEA 2020). The scenarios developed for the IEA Bioenergy Roadmap (IEA 2017a), with different levels of ambition regarding climate change mitigation, found that the higher this ambition is, the more bioenergy is needed to decarbonize the global economy – and more recent analysis from IPCC (2019) as well as work of IEA Bioenergy (Thrän et al. 2020) and the IEA Net Zero 2050 scenario (IEA 2021) highlight this finding.

To achieve the greenhouse gas (GHG) reductions required by the Paris Agreement, the bioenergy share in the global energy system would have to rise to about 100 EJ of primary energy from biomass by 2050 (i.e., 2 times the value for 2015). This increase in sustainable bioenergy supply could be obtained by mobilizing biogenic residues and wastes, and from rehabilitating degraded lands, which are substantial in many countries (Fritsche et al. 2017; IPCC 2019; IRENA 2017). The IEA bioenergy roadmap and the Net Zero 2050 scenario indicate that to achieve the required increase in biomass supply and use, appropriate sustainability governance is needed.

1.2. Bioeconomy

There are many different definitions for the bioeconomy:

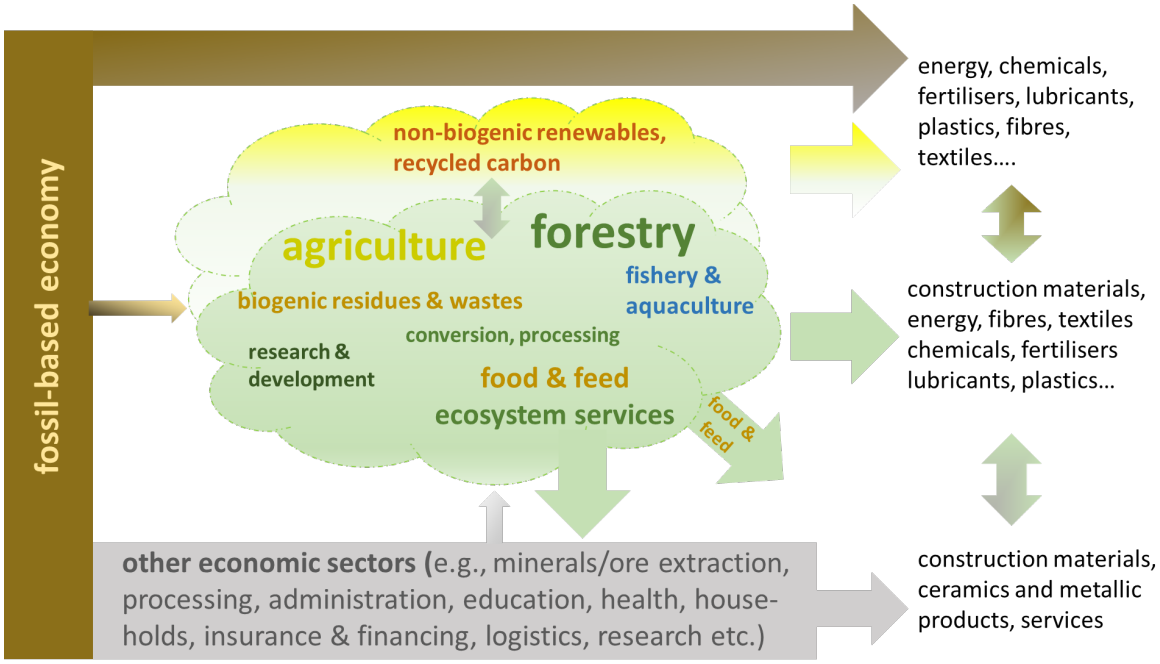
> *"The set of economic activities in which biotechnology contributes centrally to primary production and industry, especially where the advanced life sciences are applied to the conversion of biomass into materials, chemicals, and fuels."* (OECD 2017)

> *"The production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products as well as bio-energy."* (EC 2018b)

A sustainable bioeconomy is part of the renewable segment of the circular economy (Figure 1).

[6] For Europe see e.g., BIC (2018); EC (2018a-d + 2020a); EEA (2018); ENRD (2019a-e); EUBA (2018); Fritsche et al. (2020); Hetemäki et al. (2017); Motola et al. (2018); Palahí et al. (2020); Ronzon et al. (2020); for developing countries see e.g., Callo-Concha et al. (2020); Canales et al. (2020); FAO (2019); Fielding & Aung (2018); Rodríguez & Aramendis (2019).

Figure 1 Scope and system boundaries of the bioeconomy



Source: Fritsche et al. (2020); yellow- and green-shaded clouds represent renewable economy, green-shaded cloud represents bioeconomy (as part of renewable economy); right side represents outputs to society (products and services); arrows = outputs; double-arrows = substitution potentials

The bioeconomy has grown in importance and interest in the last years, especially given the potential of bioenergy to help offset dependence on fossil-based energy, helping to improve energy security while mitigating climate change. In addition, it can also incentivize economic growth, support rural development, and increase employment (ENRD 2019a-e; FAO 2019).

Currently, more than fifty countries are pursuing strategies to expand and promote their bioeconomies (Dietz et al. 2018; Teitelbaum, Boldt & Patermann 2020) with differences in pathways, priority sectors and policies (see Annex 1). In general, international and national strategies demonstrate intent and commitment, but they often lack detail (OECD 2018).

The bioeconomy - and bioenergy as part of it - is related to several SDGs and can help to achieve these goals (Blair et al. 2021; FAO 2019; Fritsche et al. 2020; Fritsche & Iriarte 2017) but faces various challenges, such as competition with fossil-based products (Dietz et al. 2018; IACGB 2020).

A growing bioeconomy implies risks and opportunities relating to the advancement of the SDGs**,** as summarized in Table 1.

Table 1 Impacts of the bioeconomy on the SDGs

SDG	Assessment of impacts	
	Positive	Negative
2. Zero hunger	Changed land management activities such as remediation of soil quality through incorporation of more organic matter in soil (as part of climate change mitigation measures) could improve crop yields. Restoring land of low quality to agricultural productivity increases available land for food/ feed and bioeconomy.	Expansion of non-food/feed biomass crops and forests could compete for land needed for food production. Increased use of crop residues in bio-based value chains could lead to diversion from other uses (e.g. animal feed) or lower organic matter inputs to soil (productivity impacts, GHG emissions).
6. Clean water and sanitation	Changed land management (e.g. perennial instead of annual crops, better soil management, more diverse landscapes of crops and forests) could reduce nutrient and sediment runoff into aquatic systems. Wastewater use for non-food cropping can improve sanitation, increase crop yields and ability to grow on low quality land.	More intensive use of land for agricultural biomass production, increased use of fertilizers (e.g. for biomass crops), and increased forest harvesting (e.g. for GHG emissions displacement) could increase nutrient and sediment runoff into aquatic systems.
7. Affordable and clean energy	Increased biomass production and local use for energy could increase energy security for local communities. In traditional electricity systems, power from biomass offers baseload. Dispatchable bioenergy (biogas, biomethane) contributes to flexibility in electricity systems with high shares of fluctuating renewable generation.	Restricted access to forest resources (as part of measures to conserve forest carbon stocks) could limit the utilization of forest biomass as a bioenergy source. Cultivation of monoculture plantations can pose risks to biodiversity and other ecosystem services.
8. Decent work and economic growth	More diverse land use could provide better opportunities for income generation and wider range of job roles and skills. New business models will be introduced, offering farmers and foresters important roles in supplying non-food biomass.	Local or regional over-reliance on biomass production could reduce economic resilience. Child labor and insecure land tenure when cultivating biomass can have negative social impacts.
12. Responsible consumption and production	Increased biomass recycling and incineration of biomass with energy recovery could reduce waste and increase the supply of renewable products.	See SDG 2 comments. Increased use of some waste wood residues could redirect supplies from manufacture of composite wood products, increasing GHG emissions.
13. Climate action	More biomass use could increase C sequestered in biomaterials and mitigate GHG emissions from fossil energy when bioenergy emissions are low; BECCS for "negative" emissions. Restoring forests and landscapes and improving agricultural land use can sustain C stocks/sinks and addresses ecosystem adaptation/resilience. Restoration of unused, abandoned and degraded land and low intensity crop management could increase soil C.	More intensive use of land for agricultural and/or forest biomass production; increased use of fertilizers could lead to reduced soil C stocks and increased GHG emissions. Utilization of biomass resources may increase GHG emissions due to land use and soil C changes.
14. Life below water	Not determined due to current minor relevance for the EU – but large regional differences, and rising interest for the blue bioeconomy, and of increasing future relevance, especially for algae and aquaculture.	
15. Life on land	Reduced intensity of biomass crop management and conservation of forest areas could support ecosystem restoration and safeguard biodiversity. Restoration of unused, abandoned and degraded land will increase opportunities for raw material supply and rural development. Increased economic value for crops and forests (either as biomass sources or valued C reserves) could give incentives for protection of agricultural land and forests. Better managing undermanaged forests improves habitat provision in some situations.	Greater pressure on agricultural land and forests from demand for food and bioenergy/materials could lead to over-exploitation and degradation of ecosystems and possibly ecosystem loss. Cultivating non-food crops with unsustainable practices will increase soil compaction and reduce soil organic C. Increased removal of agricultural and forestry biomass residues could lead to loss of soil nutrients and structure with negative effects on crop and forest productivity.

Source: adapted from Fritsche et al. (2020)

2. Governance of Bioenergy and the broader Bioeconomy

2.1. What is Governance?

The Encyclopaedia Britannica[7] defines governance as

> *"patterns of rule or practices of governing. The study of governance generally approaches power as distinct from or exceeding the centralized authority of the modern state".*

According to Wikipedia[8], governance

> *"…is all the processes of interaction be they through the laws, norms, power or language of an organized society over a social system (family, tribe, formal or informal organization, a territory or across territories). It is done by the government of a state, by a market, or by a network. It is the decision-making among the actors involved in a collective problem that lead to the creation, reinforcement, or reproduction of social norms and institutions".*

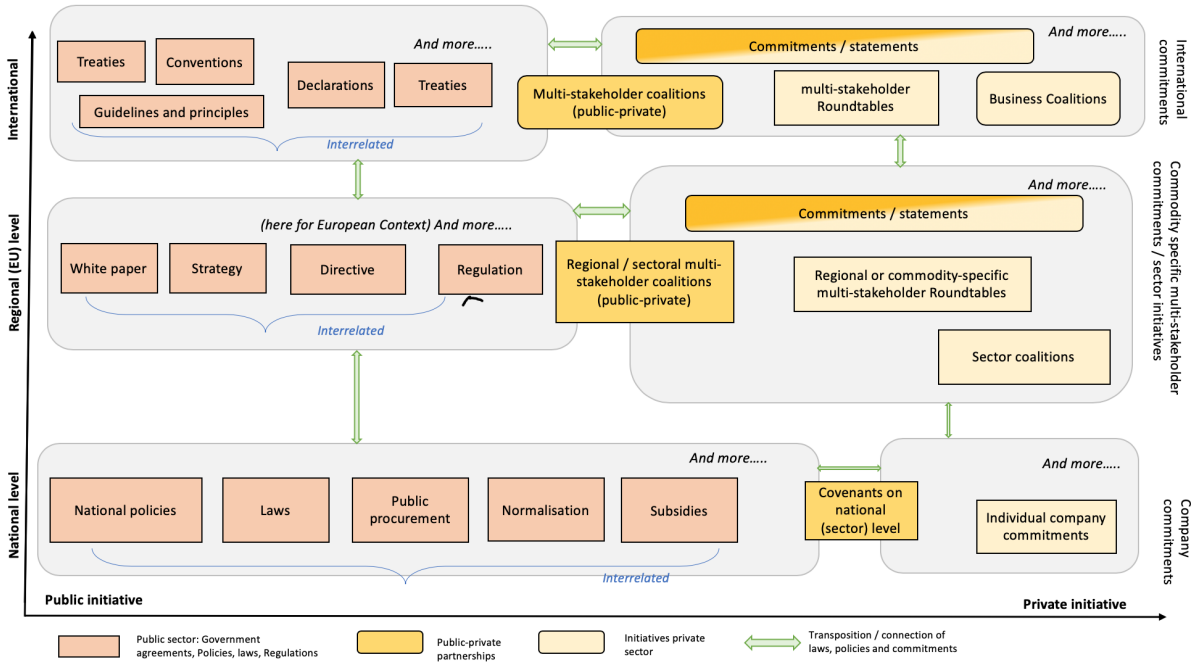
Meuleman (2019) defines governance in short as how societal challenges are tackled and opportunities are created. This definition focuses on the question of 'how to get things done', not on 'what should be done'[9]. In addition to "hard" governance expressed through laws, contracts, and similar legally binding arrangements there are soft mechanisms, i.e., commitments and non-binding rules.

As regards sustainability, governance is crucial to achieving the SDGs (Mechler et al. 2021), and inclusiveness is seen as a key issue in that (CH 2021).

Biermann & Kim (2020) give a brief overview of current international governance structures and their perspectives towards "planetary stewardship", while Bößner, Johnson & Shawoo (2021) focus on international governance structures and future opportunities for the bioeconomy.

The following figure maps various governance approaches on several levels and according to their position in the public or private domains.

Figure 2 Conceptual mapping of governance approaches across levels



Source: own elaboration

7 https://www.britannica.com/topic/governance
8 https://en.wikipedia.org/wiki/Governance
9 More detail on governance is given in the Annexes 2 to this paper.

2.2. Bioenergy Governance

Biomass feedstocks for energy are produced in the primary (agriculture, fishery, forestry) and waste sectors, and their use for energy concerns electricity, heat, and transport fuels. This cross-cutting nature of bioenergy brings complexity since there are areas of competition along the various biomass value chains (Londo et al. 2018).

Bioenergy governance occurs at different levels which comprise multiple coexisting regimes without the establishment of a single comprehensive agreement (Naiki 2016):

- There is no international institution governing bioenergy (Bößner, Johnson & Shawoo 2021). However, the Global Bioenergy Partnership (GBEP)[10] brings together public, private, and civil society stakeholders in a joint commitment to promote sustainable bioenergy. Also, there are international platforms promoting certain types of biofuels such as the sustainable Biofuels Innovation Challenge[11].
- At the European level, the updated Renewable Energy Directive RED II (EU 2018)[12] extended its sustainability requirements to all forms of bioenergy and is to be transposed into national laws by mid-2021. The requirements are binding not only for domestic bioenergy but also for imports from outside of the EU. The RED is a co-regulation approach (see Section 3.1.3) making use of approved private certification schemes (see Section 5.1.3) to demonstrate compliance with the sustainability requirements.
- There is much national legislation and other regulatory frameworks, e.g., feed-in tariffs and quota systems for renewable energy, including bioenergy, in many countries: Brazil, China, several EU Member States[13], South Africa, Thailand, the UK, and the US, among others, have specific regulation concerning biofuels, especially regarding food security and – more recently - GHG emissions, and Canada as well as Japan is working on such national regulation.
- Voluntary standards that can be used to show compliance with legal requirements (such as EU legislation). With the increasing number of private certification schemes not only in the sustainable bioenergy domain (see Section 3.2.3), legitimacy becomes an important element, as private schemes are not generally considered to be legitimate regulatory authorities (Stupak, Mansoor & Smith 2021).

The necessity for cross-sectoral coordination of support policies and sustainability regulations in the different energy market segments (electricity, heat, transport fuels) constitutes a governance challenge for the bioeconomy (Fritsche et al. 2020). To guide the coordination between policy instruments and create a reliable planning environment for market actors, clear and credible criteria for a prioritization of utilization options are needed.

Above all, this requires policy makers to clarify the hierarchy of policy objectives, and to provide an integration with requirements "outside" of bioenergy regulation, e.g., agriculture, biodiversity, climate, forestry, and waste management[14].

As it is expected that sustainable bioenergy supply and use will increase globally (see Section 1.1), the interlinkages with existing "outside" requirements on the one hand and the need to adjust regulation "inside" of the bioenergy domain will increase. With climate change mitigation, biodiversity protection as well as human (land) rights being policy issues of increasing global relevance, the need for integration becomes even stronger.

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10 http://www.globalbioenergy.org/

11 http://mission-innovation.net/our-work/innovation-challenges/sustainable-biofuels-challenge/

12 Note that the EC proposal for a further revision to RED III was recently published (EC 2021b) and is now in negotiations with the EU Parliament, and the Council.

13 The EU RED and RED II are binding for Member States as minimum standards to be transposed into national law, but while doing so, stricter criteria and standards can be implemented, as in e.g., Denmark, Sweden, and The Netherlands.

14 The recent "fit for 55" package of the EC (https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541) is such an integration and prioritization example regarding the EU net zero 2050 climate goal. Together with EC activities to adjust EU regulation concerning agriculture, biodiversity, forestry, land use, and resource efficiency under the "European Green Deal" goals (EC 2019) and the upcoming review of EU Bioeconomy Strategy (planned for 2022), this represents an interesting approach towards "integration". Yet, it needs to be seen how the European Parliament and EU Member States (represented in the EU Council) will react to the EC proposals.

2.3. Sustainability governance in agriculture and forestry

Before bioenergy became a global issue in the early 2000s (and the bioeconomy since about 20109, sustainability governance has been an issue for agriculture and forestry since the 1990s.

Sustainability in the agriculture sector has been pushed for by international organizations such as the Food and Agriculture Organisation of the United Nations (FAO), and United Nations Environment Programme (UNEP), as well as in in the context of EU Common Agriculture Policy[15] and also by private standards such as the EUREPGAP[16], among others. Much of the discussion concerns specific commodities and their impact on deforestation (e.g., palm oil, soy) and the potential role of organic farming as a "sustainable practice".

In line with the EU sustainability considerations within the Farm to Fork Strategy (EC 2020b), the EU Commission will make a legislative proposal for a framework for a sustainable food system before the end of 2023 and work on common definitions and general principles and requirements for sustainable food systems and foods[17].

As regards forestry, the Forest Principles were adopted at the Rio Summit in 1992 (UN 1992) after a series of international negotiations which discussed criteria and indicators (see Section 2.5) for sustainable forest management. As the Rio Summit failed to agree on a binding "Forest Convention", a group of businesses, environmentalists formed the Forest Stewardship Council (FSC)[18] which launched its voluntary forest certification scheme in 1994. The Programme for the Endorsement of Forest Certification (PEFC)[19] was created in 1999 as an additional voluntary scheme by small and family forest owners in Europe.

Since the 1990s, a key issue of forest governance has been to reduce deforestation from illegal logging, and many national and international forest governance initiatives developed since then (Figure 3).

Figure 3 Timeline of actions to fight illegal logging

Source: http://www.flegt.org/flegt-global

15 https://ec.europa.eu/info/food-farming-fisheries/sustainability/sustainable-cap_en
16 https://www.globalgap.org/uk_en/who-we-are/about-us/
17 More details here: https://www.europarl.europa.eu/news/en/headlines/society/20200519STO79425/creating-a-sustainable-food-system-the-eu-s-strategy
18 https://fsc.org/en
19 https://www.pefc.org/

The EU FLEGT (Forest Law Enforcement, Governance and Trade) has played a central role in regulating cross-border trade of illegally harvested timber[20]. This led to enacting the EU Timber Regulation, with similar national laws such as the US Lacey Act, Japan's Clean Wood Act, etc. (see Figure 3). These governance approaches apply internationally, i.e., consider transnational trade of timber, and aim to reduce the risk of illegally harvested wood products[21].

The New York Declaration on Forests (NYDF)[22] endorsed at the UN Climate Summit in 2014 set ambitious targets to end natural forest loss by 2030, calling for supporting the private sector in eliminating deforestation from the supply chains of major agricultural commodities including soy, beef, palm oil and paper by 2020. The Amsterdam Declaration on Deforestation[23] and the Amsterdam Palm Oil Declaration[24] followed in 2015 with 9 European countries becoming signatories. Also, sustainable forest management is considered within the SDG 15 in general and target 15.2 in particular.

Forest value chains are complex with a connection to a wide variety of end products such as bioenergy, building and construction materials, chemicals, furniture, pulp and paper etc. and often concern international trade. There are several international initiatives to enhance sustainability governance of forest supply chains including certification schemes, e.g., the NYDF Global Platform, Consumer Goods Forum[25], CDP Forest[26], etc.

In summary, forest governance can be seen as double dynamic:

- On the one hand, "hot spots" such as illegal logging and commodity-related deforestation (e.g., from increasing palm oil and soy production) has received much governmental attention and respective action.
- On the other hand, the broader sustainability discussion around forests (e.g., biodiversity, climate change mitigation, sociocultural aspects) manifested in various voluntary sustainability certification schemes.

As of now, the "sectoral" approaches on various governance levels are running in parallel, with missing integration, i.e., neither agriculture nor forestry policies are aligned with increasing demands for biomass. The recent EC Forest Strategy states that

> *"[…] the Commission will propose an EU forest governance system that promotes policy coherence and synergies between the different functions a sustainable and climate neutral European economy requires forests to deliver […]" (EC 2021c).*

The future will show if such an EU initiative will deliver on this ambition, and - similar to FLEGT - bring forward national and international uptake.

2.4. Bioeconomy Governance

Given the close interaction of agriculture, forestry, food and the materials and energy sectors it seems appropriate to consider all uses of biomass under the bioeconomy concept (see Section 1.2). Yet, as of today, there is no coherent or comprehensive governance framework for the bioeconomy (Bößner, Johnson & Shawoo 2021; Dietz, Rubio & Börner 2020; Fritsche & Rösch 2020). Instead, many different types of policies with different scopes and degrees of detail exist, often lacking measurable targets (STAR-ProBio 2018).

However, at least on the EU level, the European Green Deal has the ambition to mainstream sustainability - especially climate change mitigation, biodiversity protection, and resource efficiency -

[20] See more information about the program: https://www.euflegt.efi.int/home
[21] For national and international governance activities regarding illegal logging see http://www.flegt.org/flegt-global
[22] https://forestdeclaration.org
[23] https://ad-partnership.org/about/
[24] https://ad-partnership.org/commodities/palm-oil/
[25] https://www.theconsumergoodsforum.com/
[26] https://www.cdp.net/en/forests

into all EU policies and pursuing green finance and investment and ensuring a just transition (EU 2019). In light of the conclusions of the review of the 2012 EC Bioeconomy Strategy (EC 2018a), the updated version (EC 2018b) already considers sustainability more prominently, but a review under the European Green Deal goals will only come in 2022. As of now, there is a complex web of bioeconomy-relevant laws, regulations, and directives, and specific ones associated to certain products, sectors, or markets (STAR-ProBio 2018). There are three types of bioeconomy policies, as summarized in Table 2.

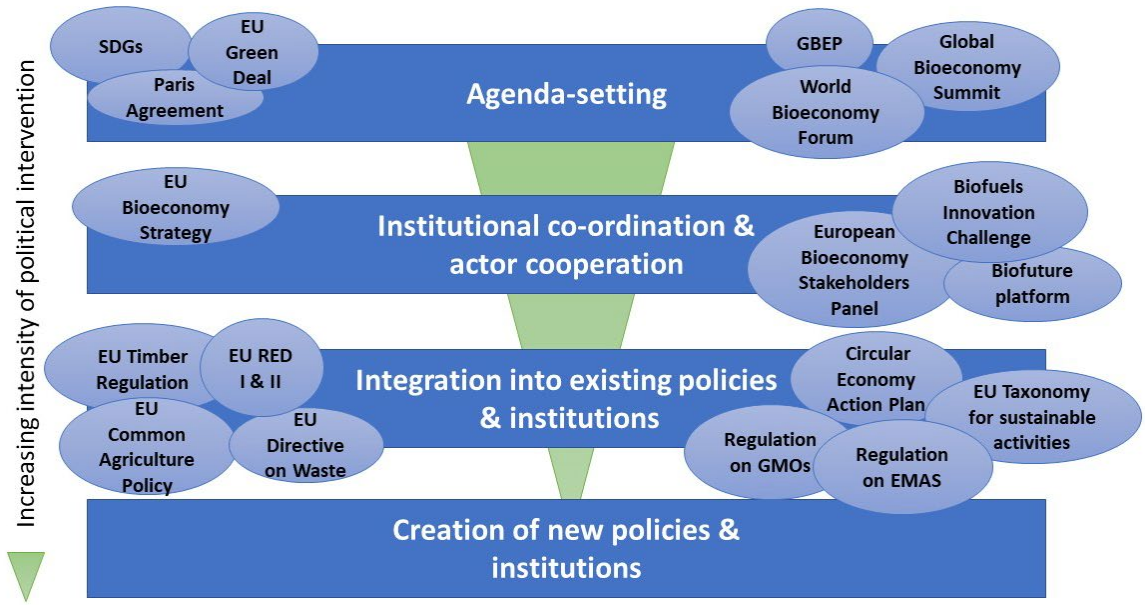
Table 2 Policies for governing the bioeconomy

Supply side: Feedstock/technology push	Demand side: Market pull	Both sides: Cross-cutting
Access to feedstocks	Targets and quotas	Standards and norms
	Mandates and bans	Certification
R&D subsidy	(Green) Public procurement	Skills and education
Pilot and demonstrator support	Labels and raising awareness	Regional clusters
Flagship financial support	Direct financial support for bio-based products	Public acceptance
Tax incentives for industrial research and development	Tax incentives for biobased products	Knowledge-based capital
Improved investment conditions	Incentives related to GHG emissions (e.g., emission trading)	
Regulation	Taxes on fossil carbon	
	Removing fossil fuel subsidies	"Greening" finance

Source: own compilation based on STAR ProBio (2018) and OECD (2018)

The following figure shows various governance approaches in the EU and their links to international activities on governing a sustainable bioeconomy.

Figure 4 Pathways towards governing a sustainable bioeconomy



Note: Only EU Directives, Strategies or Directives are considered

Source: own elaboration; RED = Renewable Energy Directive; GMOs = genetically modified organisms; EMAS= environmental management and auditing system

The impact of the current policy framework for the bioeconomy seems to be quite limited. This might be because of the non-binding character and early stage of these frameworks (STAR-ProBio 2018). On the international level, there are fora promoting the bioeconomy such as:

- The International Bioeconomy Forum is a co-owned platform, organized in ad-hoc working groups, to guide international cooperation on a limited number of R&I priorities and horizontal activities which are crucial for the development of a global, sustainable bioeconomy and addressing related global challenges (SDGs, circular economy, sustainable food security, etc.)[27].
- The Global Bioeconomy Summits[28] held in 2015, 2018 and 2020.
- The Biofuture Platform, now an initiative of the Clean Energy Ministerial[29]

The importance of promoting a sustainable bioeconomy has been underlined by several authors. OECD (2017) indicates the need of governance policies to uphold sustainability goals without presenting undue trade barriers. Considering the approaches discussed by van Dam (2019) for forests, there might be two approached to improve bioeconomy governance:

- Create a strong bioeconomy framework / platform on sustainability, or
- mainstream the concept of a sustainable bioeconomy in existing international initiatives, platforms, commitments, and policies.

Sustainability governance in the EU bioeconomy is characterized by sectors with (energy) and without (food, feed, materials) legally binding sustainability criteria. In consequence there is missing compatibility between the existing frameworks, and consequently a lack of harmonization and standardization activities (Majer et al. 2018).

An increasing cross-sectoral compatibility and recognition between the different certification frameworks of the various sectors of the bioeconomy might be also required – especially as typically small volumes of different types of feedstocks are mixed and merged in the value chain.

In summary, sustainable bioeconomy governance challenges (Dietz et al. 2018) are:

- How politics can support the rise of the bioeconomy through appropriate political means (enabling governance). States are currently highly active in addressing this point.
- Identification and effective political management of conflicting goals. The political management of conflicting goals has not yet reached the same level of attention.

2.5. How to Measure Sustainability of the Bioeconomy: Criteria and Indicators

Sustainability governance requires to establish measurements of "sustainability", i.e., to operationalize the concept through evidence-based criteria and respective indicators. Already in 2011, the Global Bioenergy Partnership established a set of indicators to measure the sustainability of bioenergy on the national level (GBEP 2011) that has been applied in several countries (GBEP 2020; IINAS 2020).

With growing policy interest in the broader bioeconomy, this "basic set" has been the foundation for extensions to address non-energy sustainability issues of the bioeconomy (Calicioglu & Bogdanski 2021; Iriarte & Fritsche 2014), and respective research is ongoing (Bringezu et al. 2021; Cucuzzella, Welfle & Röder 2020; D'Amato & Korhonen 2021).

Given the rising interest in the bioeconomy's sustainability governance, a transdisciplinary approach to develop an internationally agreed set of criteria and indicators for the sustainability of the bioeconomy is needed to provide a sound base for further policy development[30].

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27 https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=ibf

28 http://gbs2018.com/home/

29 http://biofutureplatform.org/

30 IEA Bioenergy Task 45 is currently working on a project on "Indicators to measure, monitor and assess bioeconomy sustainability (IMMABS)" as a collaborative effort including e.g. the European Commission Joint Research Centre. Results are expected by the end of 2021.

3. Sustainability Governance Approaches related to Bioenergy and the Bioeconomy

Bioeconomy governance is a complex field given the variety of actors, sectors, and interests interacting. There are different approaches to safeguard or enhance the sustainability of the bioeconomy. To assure that sustainability requirements are indeed fulfilled, such approaches should be accountable (ISEAL 2018) and based on principles such as assessment of risk, participation, and monitoring (see Annex 3).

3.1. Cross-cutting Approaches

There are several horizontal approaches which are cross-cutting sectoral boundaries.

3.1.1. Law-Making

Law is a powerful instrument for (re)shaping the policy arena. Although laws generally reflect the interests of those actors with greater bargaining power, law has also proven to be an important instrument for change. State law, however, is but one of many rule systems that order behavior, authority, and contestation. Such legal and normative pluralism is neither inherently good nor bad: it can pose challenges, but it can also generate opportunities (WB 2017a).

In the case of the bioeconomy, many legal requirements exist, both in producing and consuming countries. These requirements are, however, often scattered among sectors (agriculture, energy, food, forestry…)[31] or concern specific issues (biodiversity, climate change, land, water etc.).

Regarding international law, multilateral agreements under the World Trade Organization (WTO) regulate trade between most countries, even if many countries and regions also have bi- and multilateral trade agreements. Here, the reform of the WTO rules to include sustainability issues in cross-border trade is crucial for the bioeconomy (Fritsche et al. 2020), and considerations for a "sustainable" WTO reform are ongoing (Fiji et al. 2019; Schneider-Petsinger 2020; Voituriez & Laurans 2020).

3.1.2. Financial Regulation

As bioenergy and bioeconomy require investments for facilities and infrastructure, the respective financing through banks and other finance institutions is another area of sustainability governance.
International financing institutions such as e.g., the World Bank[32], Global Environment Facility[33], Green Climate Fund[34], and the European Investment Bank[35] but also national institutions (e.g., in France, Germany, Japan, USA) have developed internal standards to safeguard their investment portfolios and lending regarding sustainability[36], and some of that concerns bioenergy and the bioeconomy, especially liquid biofuels[37].
A broader governance concept addresses the financial markets and establish respective taxonomies (OECD 2020). The EU Taxonomy Regulation is such a framework with legal disclosure obligations for financial markets, large companies, and EU Member States (EU 2020). This regulation will be supplemented by delegated acts which contain technical screening criteria for determining when an economic activity can be considered sustainable (EC 2021a). In other words, the EU Taxonomy is a classification system for economic activities considered to contribute significantly to environmental

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31 See Section 2.3 for a brief discussion of agriculture and forestry governance.
32 https://www.worldbank.org/en/home
33 www.thegef.org
34 https://www.greenclimate.fund
35 https://www.eib.org/en/index.htm
36 A broader concept are the Principles for Responsible Banking developed by UNEP's Financial Initiative (https://www.unepfi.org/banking/bankingprinciples/).
37 e.g., IDB (2008). For overall sustainability safeguards, see EIB (2018); IDB (2018); WB (2017b); WB (2020).

objectives[38] for investment purposes. Its focus is to contribute to achieving the Paris Agreement and "do no significant harm" to other environmental goals. It is a tool for investors, companies and bond issuers to navigate the transition to a low-carbon, resilient and resource-efficient economy.

Other sustainability governance related to finance concerns voluntary systems in the bonds markets, some of those specifically dedicated to bioenergy (e.g., CBI 2020)[39].

3.1.3. Public-private co-regulation

Co-regulation is a combination of public law-making (regulation) with private activities and gained ground during the 1990ies. In the US, co-regulation was used with a focus on government-industry collaboration (Balleisen & Eisner 2009).

In the EU is the mechanism whereby a European-level legislative act entrusts the attainment of the objectives defined by the legislative authority to other parties, e.g., economic operators, non-governmental organizations, or associations (EC 2003). This mechanism's criteria may be defined in legislative acts to enable the legislation to be adapted to the actors concerned,

> *"[…] to reduce the legislative burden by concentrating on essential aspects and to draw on the experience of the parties concerned Co-regulation makes use of public regulation and private mechanisms that can freely operate internationally (such as many certification schemes)."* (STAR Pro-Bio 2020a)

In this respect and as described by Ugarte (2015), the concept of co-regulation means that countries define legislative sustainability obligations for supply chains of a certain economic sector and allow private control mechanisms (e.g., certification or due diligence) to demonstrate compliance. A well-known example co-regulation instrument in the EU is within the Renewable Energy Directive (RED), where meeting sustainability criteria can be demonstrated through certification schemes recognized by the EC (EU 2018).

The EU research project STAR Pro-Bio (2020a) identified four types of co-regulation approaches for bio-based products:

- Binding sustainability criteria and verification.
- Binding sustainability requirements and non-required verification.
- Recommended sustainability requirements.
- Required disclosure and non-binding sustainability criteria

Moreover, the project developed guidelines for an overarching co-regulation framework using sustainability assessment tools for the bioeconomy.

3.2. (Global) Supply-chain Governance

Global supply chain governance is a system of rules (regulations, standards), structures and institutions that guide, control, and lead supply chains. Examples of such laws and policies in Europe are the EU RED on the sustainable production of biofuels and bioenergy, the EU timber regulation which aims to counter illegal logging and associated trade in timber and timber products in the member states of the EU, and various approaches towards "deforestation-free" supply chains (BMEL 2020; TI 2020).

Another example is the Indonesian Sustainable Palm Oil (ISPO) certification as mandatory requirement for all oil palm growers and millers operating in Indonesia. Companies operating and trading between these countries, need to comply with these sustainability requirements. Next to that, a growing number of companies, and private initiatives (e.g., the Consumer Goods Forum) have adopted sustainability commitments.

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[38] Now only for climate change adaptation and mitigation. The EU Taxonomy will be extended for other objectives in the future.

[39] For a brief discussion of voluntary sustainability standards see Section 3.2.3.

There are various possibilities for companies to demonstrate compliance with sustainability criteria, or to minimize risk, through the supply chain of the company: certification schemes, verification, or Due Diligence (or a combination of them). Certification schemes, verification protocols and Due Diligence have their own rules, procedures, and guidelines in place for their auditors and inspection bodies to monitor and verify compliance with the criteria, or to minimize risk, as laid down in their standard.

An important component of such systems is the Chain of Custody (CoC). The CoC forms the basis for any claims that can be made about the approved or certified product. The supporting assurance system (including auditing, oversight, reporting, claims approval, etc.) is used to verify that the actor involved has met the requirements of the CoC Standard and supporting policies. There are different CoC models to track products and associated claims through a supply chain (e.g., segregation, mass balance, book and claim), with varying level of detail on the product source and its sustainability characteristics, and complexity of implementation (ISEAL 2016).

Regarding a potential future transnational sustainability certification for the bioeconomy which goes beyond the "willing few" companies, Vogelpohl (2021) raises questions on the political acceptance in exporting countries which need consideration in the governance perspectives (Section 4).

3.2.1. Due Diligence

The due diligence system basically consists of operators undertaking risk management regarding illegally produced commodities on markets. For example, the EU requires due diligence for timber (EU 2010) and for conflict minerals (EU 2017). At the country level, France adopted a law imposing due diligence on multinationals. Voluntary sustainability standards (see Section 3.2.3) can be a part of corporate due diligence policies (ISEAL 2020).

Table 3 Country examples for due diligence regulations requirements

Country	Example
FR	French Duty of Vigilance Law 2017: Regulations imposing general mandatory human rights and environmental due diligence
NL	Child Labour Due Diligence Act 2019: Regulations imposing issue-specific mandatory due diligence
UK	UK Modern Slavery Act 2015: Regulation imposing reporting requirements
EU	Non-Financial Reporting Directive
EU	Timber Regulation Conflict Minerals Regulation

Source: own elaboration

The EC is expected to present a legal proposal – a directive - on sustainable corporate governance in 2021 which may include mandatory cross-sectoral due diligence covering human rights and environmental (climate) standards and would cover the full supply chains of companies. This may be an "umbrella" regulation covering the broader bioeconomy as well.

On the UN level, the "Guiding Principles on Business and Human Rights" (UN 2011) serve as the global framework for Due Diligence, but are voluntary in nature.

3.2.2. Business-to-Business (B2B)

Business-to-business governance means companies working directly with their supply chain actors on applying sustainability standards. The Consumers Good Forum (CGF) is a global network of such companies, bringing together consumer goods retailers and manufacturers and help them to secure consumer trust and drive positive change. The CGF has created the so called "Coalitions of Action" to

approach this issue more effectively, and works to improve various aspects of the sustainability of the consumer good industry, as for example:

- Environmental sustainability: Forest Positive Coalition, Plastic Waste Coalition, Food Waste Coalition.
- Social sustainability: Human-Rights Coalition – Working to End Forced Labor and Sustainable Supply Chain Initiative

The Sustainable Supply Chain Initiative (SSCI) is a new initiative developed by the CGF. It is a program which benchmarks and recognizes sustainability standards. The SSCI gives guidance on which third-party auditing and certification schemes cover key sustainability requirements and apply relevant governance and verification practices.

Another tool is the ITC Standards Map[40], where more than 260 standards can be compared on their requirements for environmental protection, worker and labor rights, economic developments, quality and business ethics.

3.2.3. Voluntary Standards

Voluntary Sustainability Standards (VSS) are a form of private market regulation with varying objectives, and include redistributing wealth, protecting people and the planet, ensuring consumer safety, mitigating supply chain risk, and attracting green consumers (Bennett 2017). VSS were developed by companies, and sector or multi-stakeholder initiatives, often in partnership with a range of non-governmental actors such as civil society groups. The key point of VSS is that using certification, such schemes provide producers with market incentives to opt for more sustainable production, thereby bringing greater surety and transparency to the management of sustainable supply chains.

VSS schemes can also increase consumer awareness around issues such as ethical production, producer well-being, and corporate social responsibility (UNFSS 2016 + 2018)[41]. The latter might contribute to governing business to consumer (B2C) relations.

Certification might be appropriate to ensure a safeguard for certain risks, based on well-defined indicators (STAR-ProBio 2018) and assurance requirements – and it may well need an overall framework (such as the SDGs) and a clear understanding and some sort of control perspective on the absolute amounts of biomass which can be used sustainably (planetary boundary concept)[42].

Most of these standards are voluntarily adopted by the parties concerned in a practice called 'self-regulation' or might be used by public bodies in the so-called co-regulation (see Section 3.1.3).

3.3. Landscape and Jurisdictional Governance related to Sourcing Regions

A new approach, still in development, is the governance by landscape or jurisdictional region motivated by, among others, sustainable commodity production for exports (Diaz-Chavez & van Dam 2020).

> *"…integrated approaches to governance which address whole landscapes and regions might have higher potentials to deal with the land use changes and the joint impact of different land uses and sectors on the commons." (Stupak et al. 2019)*

The sustainability governance of landscape approaches is to be conducted on a regional level, and not for the individual property, company, or product. Thus, while the traditional verification unit of certification schemes is the farm, plantation or mill, the verification unit for regional approaches is a specific geographical area (van Dam 2020). Benefits of action at landscape scale include for example

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40 https://www.sustainabilitymap.org/home

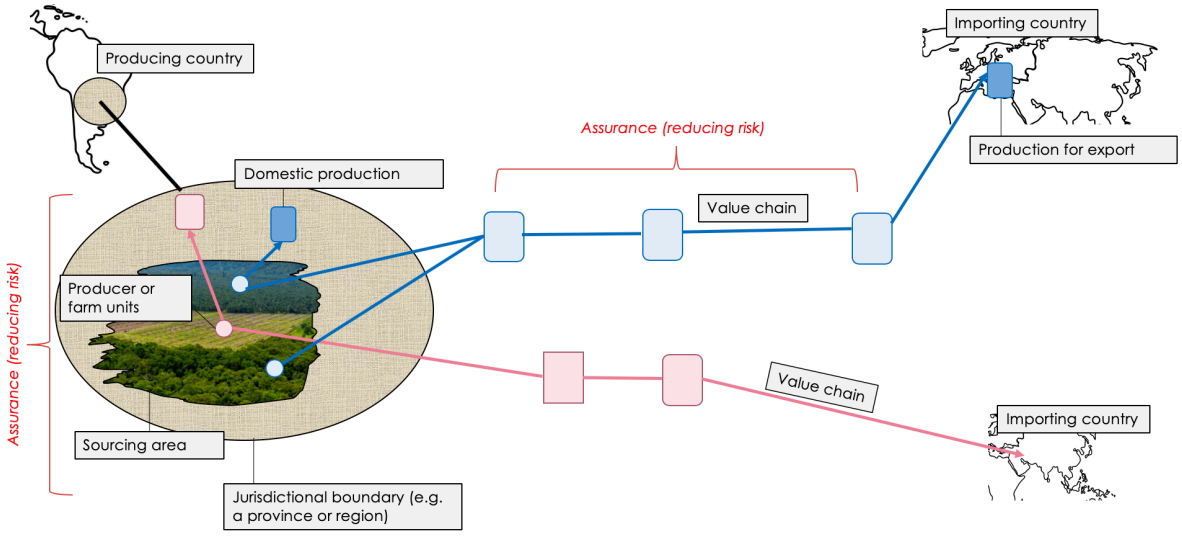
41 Interestingly, a recent conference in Southern Africa addressed this issue, see https://unfss.org/2019/10/14/bioeconomysouthafricameeting2019/

42 Even if the global potential of sustainable biomass is significant, there are vast regional differences both in potential supply, and use. The example of unsustainable "traditional" biomass use for cooking in many African countries clearly demonstrates that.

jointly tackling ecosystem risks that can impact company operations (e.g., soil erosion) or avoiding "leakage" of impacts from one site or ecosystem to another (Dudley, Smallwood & Chatterton 2020).

Note that landscape approaches vary in terminology, objectives, and level of stakeholder involvement. Landscape approaches are still evolving, and its evidence base is under development (Chervier, Piketty & Reed 2020; DiGiano, Stickler & David 2020). Guiding or design principles are proposed by several authors, e.g., Sayer et al. (2013), Ros-Tonen et al. (2015) and Djenontin et al. (2018). There is consensus of thought and convergence around the following key principles: the need for (i) monitoring and evaluation, (ii) for iterative and adaptive management, (iii) for addressing common concerns and for (iv) multi-stakeholder participation (Reed et al. 2020; Kusters et al. 2020).

Figure 5 The Landscape approach to reduce risks in supply chains



Source: own elaboration

The jurisdictional approach is considered a type (or sub-category) of a landscape approach that uses government administrative boundaries, primarily sub-national, to define the scope of action and involvement of stakeholders rather than social or environmental (e.g., ecosystems, watershed) boundaries (GCP 2015).

In some places, governments and companies have started working together to promote zero-deforestation through the creation of jurisdictions where the risk of (especially) deforestation is kept low, and where forest-risk commodities can be preferentially sourced (FAO 2018).

The idea of preferential sourcing is also laid down in the Verified Sourcing Area (VSA) model from the Sustainable Trade Initiative (IDH 2020): A sustainability improvement deal (a "compact") is made between buyers of commodities and stakeholder coalitions in producing landscapes at jurisdictional level, e.g., a municipality, district, or province. The degree of assurance provided by preferential sourcing from low-risk jurisdictions is considered lower than that from individual company-level certification.

However, landscape and jurisdictional standards are also developed to verify performance. One example is the LandScale (LS) standard, as a shared initiative of the Climate, Community and Biodiversity Alliance, the Rainforest Alliance and Verra (Landscale 2020). Another example is the Jurisdictional Approach for RSPO Certification which is under consultation (RSPO 2020).

As of now, the pros and cons of the new landscape and jurisdictional governance compared to the more "traditional" approaches cannot yet be valued, as there is too little evidence.

4. Perspectives for Sustainability Governance of the Bioeconomy

The importance of bioenergy and bioeconomy governance is increasingly recognized and implemented on different levels, though without comprehensive cross-sectoral and transboundary coordination. Yet, the nature of connections between primary production (agriculture, forestry, etc.) and conversion (chemicals, construction, energy, fiber, food etc.) requires considering their interactions across sectors, and beyond national boundaries.

As national SDG frameworks are in the process of being adapted and implemented, this brings the opportunity to create synergies between bioenergy and the SDGs (Blair et al. 2021; Iriarte & Fritsche 2019). As of now, the governance of national SDG implementation is weak, though, and it may well be necessary to develop a specific bioeconomy governance or "umbrella" framework such as the European Green Deal to integrate sector policies vis-a-vis the bioeconomy.

Discussions in a joint workshop of IEA Bioenergy, BioFuture Platform, FAO, GBEP and others indicate the interest of many stakeholders to work collaboratively on improving sustainability governance of the bioeconomy (Pelkman, Berndes & Fritsche 2019), and to fulfil the request of the 2018 and 2020 Global Bioeconomy Summits to improve on the international sustainability governance (GBS 2018+2020).

The possible extension of the GBEP Sustainability Indicators for Bioenergy to the broader bioeconomy may be a key opportunity to deliver on that ambition (Bößner, Johnson & Shawoo 2021), and initiatives such as the Global Bioeconomy Summits could help exchanging views and supporting alignment between countries.

Given that there is no one-size-fits-all solution, as different cultures and institutional traditions need consideration, the bioeconomy requires "*common but differentiated governance*" (Meuleman & Niestroy 2015), i.e., sustainability governance of bioenergy and the broader bioeconomy remains the responsibility of countries, but exchange and co-ordination through international and intergovern-mental platforms is necessary.

UN organizations such as the FAO, UNDP, and UNEP as well as financial institutions such as the World Bank will have supporting roles in this, and both business and civil society should contribute.

It is encouraging that the Biofuture Platform foresees to become active in shaping a sustainable governance of the bioeconomy, and the next Global Bioeconomy Summit planned for 2022 may become a forum to further build on that.

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Annex: Details on the Governance of the Bioeconomy

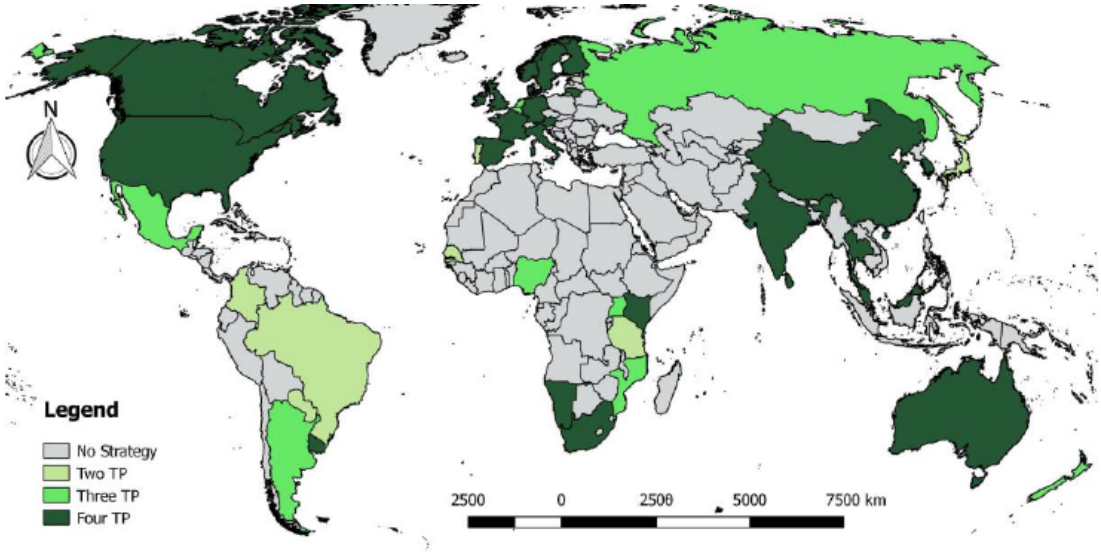
A-1 Bioeconomy Strategies

Figure 6 gives a brief overview of bioeconomy policies around the world as in 2018. Ireland and UK published dedicated BE strategies in 2018 while Austria, Canada and Italy published BE strategies in 2019. The most recent global overview is given by Teitelbaum, Boldt & Patermann (2020).

Figure 6 Bioeconomy policies around the world

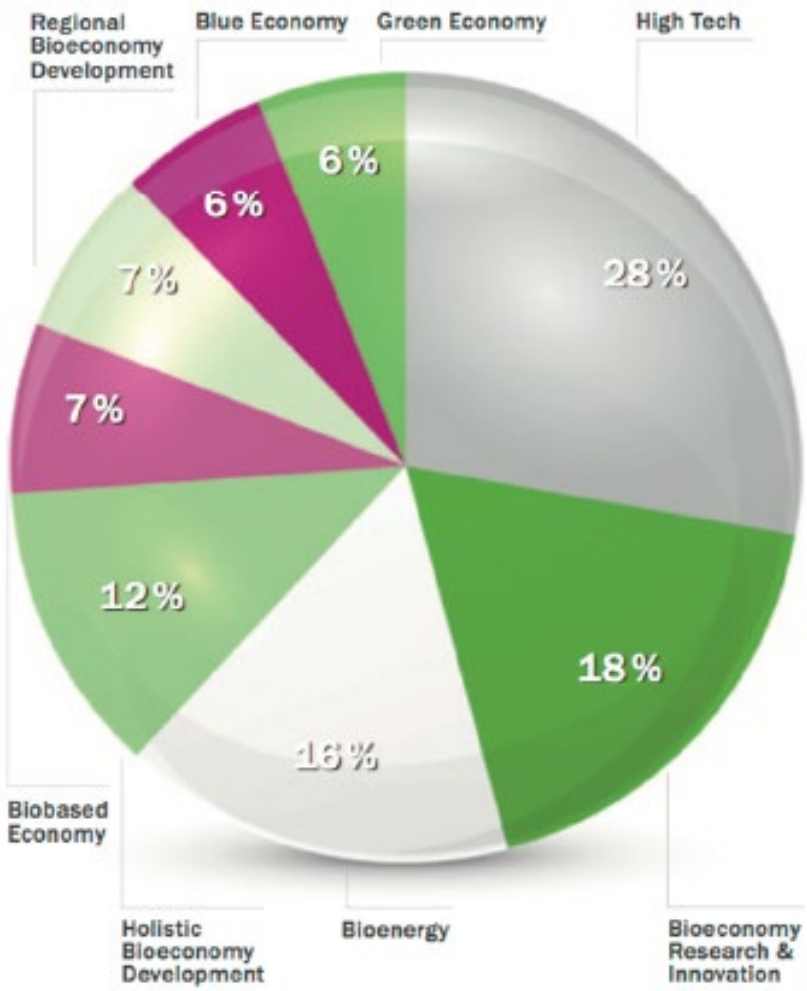
Source: BioStep (2018)

Figure 7 Transformative pathways by country



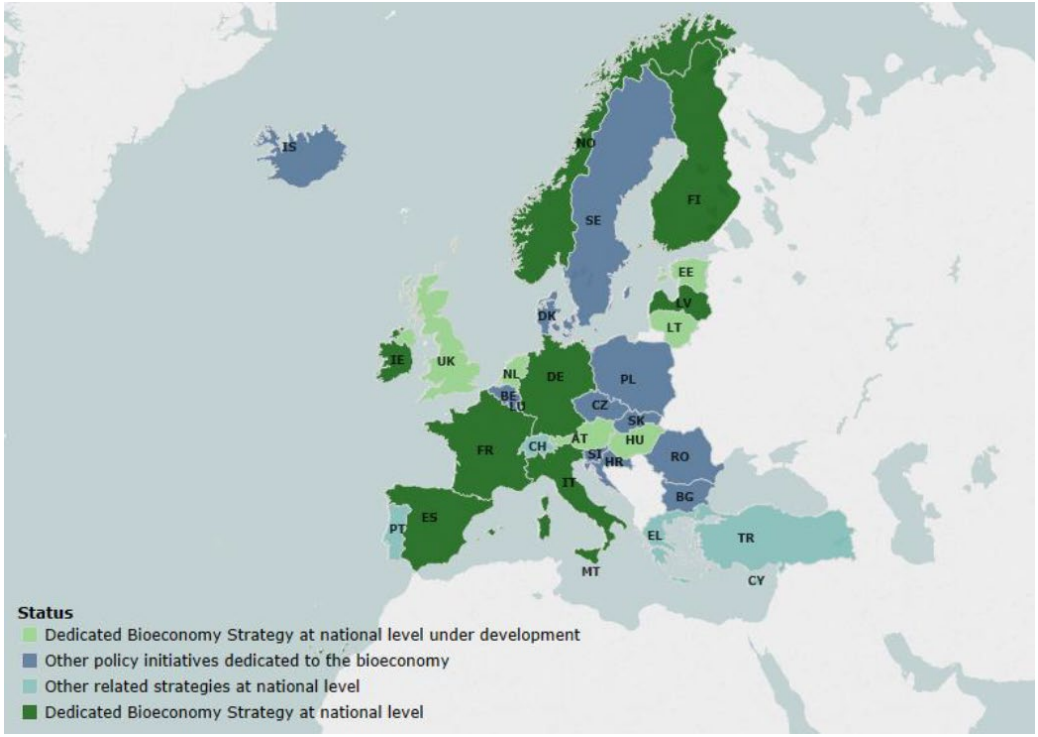
Source: Dietz et al. (2018)

Figure 8 Policy strategies related to bioeconomy development



Source: von Braun (2017)

Figure 9 Strategies and other policy initiatives dedicated to the bioeconomy in the EU Member States (status as of March 2018)



Source: Motola et al. (2018)

Table 4 Overview of regulatory mechanism by country

	State regulation	Creation of positive incentives by governments	Private standards and certification	International cooperation
Austria			x	
Denmark			x	
EU			x	
France	x	x	x	x
Germany	x	x	x	x
Ireland	x	x	x	x
Kenya			x	
Lituania	x		x	x
Mexico				
Mozambique			x	x
Norway			x	
South Africa	x	x		x
Sweden			x	x
Thailand			x	x
UK	x	x	x	x
China	x	x	x	x
Total	**8**	**6**	**14**	**10**

Source: Dietz et al. (2018)

Table 5 Bioeconomy sectors covered in different country strategies

	AR	BR	CO	CL	ES	FR	DE	EU	US
Aquaculture							X	X	
Agriculture and agribusiness	X	X	X	X	X	X	X	X	X
Food and beverages	X	X	X	X	X	X	X	X	X
Fuels					X	X		X	X
Cosmetics			X						
Energy	X	X	X		X	X	X	X	X
Pharmaceutics			X				X	X	
Forestry						X	X	X	X
Livestock	X	X	X	X	X	X	X	X	X
Industry		X			X	X		X	X
Environment			X	X		X	X	X	X
Pulp and paper								X	
Fishing	X							X	X
Plastics						X		X	
Residues		X		X	X	X	X	X	
Health			X					X	X
Silviculture				X	X	X	X	X	X

Source: adapted from Betancur et al. (2018)

Diverse national contexts demand the development of diverse bioeconomy strategies (Devaney & Henchion 2018). Scordao, Bugge & Fevolden (2017) developed a typology of three bioeconomy visions:

(1) a bio-technology vision

(2) a bio-resource vision, and

(3) a bio-ecology vision.

Dietz et al. (2018) distinguish between four **bio-based transformation paths**:

(1) substitution of fossil fuels with bio-based raw materials;

(2) productivity increase in bio-based primary sectors;

(3) increasing efficiency in biomass utilization; and

(4) value creation and addition through the application of biological principles and processes separate from large-scale biomass production.

A bioeconomy can be seen as an **umbrella policy-term** that has the effect of writing into consensus opposing views of stakeholders to provide policy language that is politically acceptable to diverse stakeholders (Mukhtarov, Gerlak & Pierce 2016).

A-2 Definitions of Governance

A Global Commission appointed by the UN-Secretary General has defined governance as *"[…] the sum of the many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated and cooperative action may be taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest..."* (CGG 1995).

Another broad definition adds the normative dimension: Governance is "*a collection of normative insights into the organization of influence, steering, power, checks and balances in human societies*" (Meuleman & Niestroy 2015).

Governance can be understood as the process by which societies adapt their rules to new challenges. Governance has a substantial dimension (what are the rules?), a procedural dimension (how are the rules developed?), and finally a structural dimension (the procedural rules and institutions that determine rulemaking, how the rules are implemented and enforced, and how conflicts over rules are resolved) (Dietz et al. 2018)

Governance can be defined by the actors and organizations that manage a resource base and define how and what rules of management should be designed and put in practice (Ostrom 2009). Governance thus incorporates not only the institutions, the rules, norms, and regulations that structure interactions, but also the actors involved, and their values, interests, and actions (Eakin, Rueda & Mahanti 2017).

> *"Governance refers to the structures, processes, rules and traditions that determine how people in societies* ***make decisions and share power, exercise responsibility and ensure accountability"*** *(Patterson et al. 2017).*

> *"Governance refers to all* ***processes of governing****, whether undertaken by a government, market, or network; whether over a family, tribe, corporation, or territory; and whether by laws, norms, power, or language. Governance is a broader term than government because it focuses not only on the state and its institutions but also on the creation of rule and order in social practices". (Cavicchi, Palmieri & Odaldi 2017)*

Beyond the concept of governance, attention is also paid to **metagovernance**, which can be defined as

> *"a means by which to produce some degree of coordinated governance, by designing and managing sound combinations of hierarchical, market and network governance, to achieve the best possible outcomes" (Meuleman 2019).*

Metagovernance is in the first place a heuristic concept that describes how public managers deal with complexity (Meuleman 2019). Secondly, it is a conceptual reply to the challenge of dealing with governance failures such as those caused by inherent weaknesses of certain governance styles or by incompatibility of governance styles. Metagovernance is not even governance, but about how to deal with governance challenges.

A-3 Bioeconomy Governance Principles

Bioeconomy governance is a complex field given the variety of actors, sectors, and interests interacting. The involvement of different stakeholders through multi-stakeholder processes helps to ensure a better balance of power over limited resources in a landscape, although this requires that time, capacity and resources are made available (Diaz-Chavez & van Dam 2020).

FAO (2019) identified several success factors on the governance of biomass production and use, among others:

- Inclusive decision-making and mechanisms for stakeholder collaboration
- Follow a territorial/landscape approach to promote rural bioeconomy development and to tackle complex issues
- Regional bioeconomy clusters can play an important part in biomass value webs
- Develop contract farming mechanisms
- A supra-ministerial body close to the top level of the government is important for managing and coordinating the development and implementation of bioeconomy strategies
- Public mechanisms (e.g., public procurement programs and public awareness campaigns) play an important role in reaching the desired levels of market uptake and consumer awareness of bioproducts.

Accountability and Transparency

A government is accountable to the public for the policies and actions it puts into effect. Accountability also applies for companies to demonstrate and take responsibility for performance in light of their commitments. Measuring accountability entails measuring a government's or company's responsibility for: (i) their performance, (ii) transparent and representative decision making and (iii) for outcome- and evidence-based policies and actions.

One of the key principles of accountability is transparency, making information about the processes accessible. Within sustainability reporting and commitments, transparency touches upon multiple issues, including for example transparency in:

- The company commitment: The Accountability Framework initiative underlines that companies that have issued supply chain commitments should publicly communicate progress towards fulfilling these commitments through their reporting and disclosure, based on commonly accepted standards and guidelines for content, completeness, clarity, accessibility, and quality (AFI 2019).
- Performance (in certification): The ISEAL Assurance Code requires for example that the scheme owner shall ensure that performance insights are provided to clients. The European Parliament underlined in its recommendations to the Commission on an EU legal framework to 'halt and reverse EU-driven global deforestation' that robust third-party certification schemes should include public disclosure of auditing reports, transparency at all stages, and openness (Burkhardt 2020).
- Making **information** understandable and freely available might also help improve communication with citizens and other stakeholders invigorating understanding, ownership and engagement. (Meuleman & Niestroy 2015; Devaney, Henchion & Regan 2017)

Many reporting frameworks and standards, including the Global Reporting Initiative (GRI), CDP Forests, the Climate Disclosure Standards Board (CDSB) reporting framework, the Greenhouse Gas Protocol Corporate Standard, and the United Nations Guiding Principles Reporting Framework (UNGP RF) provide principles for effective reporting (AFI 2020a+b).

Another aspect of accountability focuses on **measuring and monitoring performance**.

Accountability mechanisms such as enforcement and monitoring, ensuring transparency, implementing critical review panels and involving and informing the public, will be necessary to build trust

and confidence in the bioeconomy concept. An initial step towards addressing accountability may be to establishment dedicated, independent national bioeconomy councils, as in Germany (Devaney, Henchion & Regan 2017).

Monitoring and Verification

Sustainability compliance means conforming to a set of criteria. These criteria can be laid down in certain laws, regulations, standards, or other requirements. To be accountable (see 4.2), companies need to demonstrate compliance to these requirements, through measuring, monitoring and verification of data, with a certain level of assurance. Assurance can be defined as the demonstrable evidence that specified sustainability requirements are indeed fulfilled (ISEAL 2018).

Monitoring and verification (M&V) are an iterative, ongoing process that companies use to assess and demonstrate compliance, performance, and progress with respect to their supply chain commitments (AFI 2019). Along with an effective monitoring system, the verification process is a key component of a company's assurance system for demonstrating compliance with or progress towards supply chain commitments. Verification serves to assess and validate the findings of monitoring processes and other information related to social and environmental issues (AFI 2020a+).

Different approaches and methods to monitor and verify sustainability compliance exist in practice, addressing both markets with voluntary and mandatory requirements. Generally, three different levels of verification can be distinguished, which are classified based on the relationship between the company and the verifying party (AFI 2020a+b):

- First-party verification (conducted by the company itself).
- Second-party verification is conducted by a related entity with an interest in the company or operation being assessed.
- Third-party verification is conducted by an independent entity that does not provide other services to the company (e.g., through a certification standard or verification programme).

First and second-party verification are sometimes referred to as an internal audit. Third-party verification serves a valuable function as part of an overall M&V system by providing a higher level of confidence and credibility that a given level of compliance has been achieved (AFI 2020a+b).

Next to the level of verification used to monitor progress of data, other factors also define the level of assurance of the data. A credible verification process should for example have rigorous methodologies including auditable metrics (AFI 2020a+b). A landscape initiative should have good quality data about its performance and has sufficiently robust data management systems to distill insights that can be used by landscape actors to improve (Mallet et al. 2019).

In those sectors of the bioeconomy where sustainability requirements, set by national or international legislation, have become a prerequisite for participation in biomass or bioenergy specific support schemes, (voluntary) sustainability certification schemes can be used to demonstrate compliance. In that case, the legislator approves those schemes, which comply with the legislative sustainability requirements and are thus qualified to verify the compliance of market actors with existing sustainability requirements.

In some cases, the legislator also allows (in addition) to demonstrate compliance with the sustainability criteria through (additional) verification, based on a verification protocol. A verification protocol sets basic rules, procedures, and guidelines for inspection bodies to carry out verification.

Next to that, a country or companies can also decide to monitor and verify progress on regional or sector level (which are certified and/or verified) towards certain targets and policies. An example for this is the EC's monitoring of commodity price changes associated with the use of biomass for energy and any associated positive and negative effects on food security. Another example is the significant

effort of the Commission for the monitoring of the biobased economy on EU level (DBFZ 2020; Giuntolo 2020; JRC 2020a+b)[43].

Risk-based approaches

Risk-based approaches are therefore developed to assess, evaluate, quantify and prioritize sustainability risks, and determine and implement an appropriate response in terms of data collection and level of monitoring required to those identified risks (WBCSD 2016).

When looking at the sourcing area, certain schemes, such as FSC or PEFC (see Section 2.3), use for example risk-based approaches to manage the inclusion of non-certified material into their certified value chain (Proforest 2017). Under FSC, risk assessments are for example used to determine the risk of an organization obtaining material from unacceptable wood sources when sourcing controlled wood. In areas of 'low risk', organizations may source controlled wood. In areas of 'specified risk', organizations must implement a set of 'control measures' designed to mitigate the specific risks present and verify that they are effective (FSC 2018).

Some certification standards use national or regional risk assessments with the purpose of evaluating an entire geographic region and determining the risks associated with sourcing feedstock from that region. The need for individual producers to conduct risk assessments is herewith avoided (van Dam 2020). The regional risk assessment from the Sustainable Biomass Program (SBP) determines for example the risk associated with individual indicators of the standard when sourcing feedstock from that region (SBP 2017).

Participation

Participation is crucial for bioeconomy strategy development, and for engaging in bargaining, negotiation and compromise (Devaney, Henchion & Regan 2017). Participatory engagement processes can further enable affected parties to move beyond confrontational to more cooperative relationships (Zusman & Amanuman 2018).

Participation may lead to allow culturally diverse voices that could result in a rich variety of solutions to similar problems, instead of current governance practice in which centrally proposed solutions (and also concerns) are accepted in some cultures and rejected in others (Meuleman 2013).

The involvement of the civil society in the bioeconomy is only at the beginning (STAR Pro-Bio 2018). Involving different sectors of society in high-level decision-making processes is difficult, characterized by a lack of certainty over what processes and mechanisms are best employed to enable genuine participation and integrate lay expertise (Devaney, Henchion & Regan 2017). Broadening involvement in science and policy development generally may lead to more widely accepted (and perhaps better) outcomes but this is still largely untested (Upham & Dendler 2015).

Stakeholder engagement can be a critical part of the verification process, serving both to define the appropriate scope and methodology for verification activities and to furnish information and perspectives that improve the accuracy and legitimacy of verification results (AFI 2020A+B).

Multi-stakeholder consultations are often effective tools for identifying risks. Stakeholders have in most cases a very thorough knowledge of a certain area and can put together a much more nuanced picture of the risks that are associated with the area than general indices (ProForest 2017).

[43] The EU Bioeconomy Monitoring System is available as a beta version, see https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring_en

Governance Actors

Values and traditions making out cultures and have high impact on the effectiveness of governance within, between and across countries (Meuleman 2019). The need for addressing issues of **values and power** and the importance of political and social context has been highlighted by different authors (e.g., Mukhtarov, Gerlak & Pierce 2016; Meuleman & Niestroy 2015). Economic power may be a lot stronger than political power (Meuleman & Niestroy 2015).

During policy bargaining processes, the unequal distribution of power—***power asymmetry***—can influence policy effectiveness (WB 2017). Power asymmetries can be expressed as: exclusion, capture and clientelism.

There is a **variety of actors** with various values, actions, interests, knowledge, backgrounds and acting at different levels. It is the setting in which governance manifests itself. Policy arenas can be found at the local, national, international, and supranational levels. They can be formal (parliaments, courts, intergovernmental organizations, government agencies), traditional (council of elders), or informal (backroom deals, old boys' networks). Who bargains in this policy arena and how successfully they bargain are determined by the relative *power* of actors, by their ability to influence others through control over resources, threat of violence, or ideational persuasion - *de facto* power, as well as by and through the existing rules themselves - *de jure* power (WB 2017). The various dimensions often overlap, creating a complex network of actors and interests (WB 2017).

Public Administration

Institutions are central to the challenge of achieving a productive balance between stability and flexibility in governance systems (Beunen, Patterson & van Assche 2017). Institutional fragmentation is a well-discussed problem by scholars interested in international law and governance. While institutional analysis has focused substantially on effectiveness, relationship and interactions highlight that institutional complexity is typically analyzed as separate cases (Ahlström & Cornell 2018). The quality of the institutions is also a relevant aspect to be considered. It is needed to pay **more attention to how institutions function and less to the specific form they take** (WB 2017).

National governments have unique, powerful tools including taxation and spending, allocation and enforcement of property rights, regulation and its enforcement, and coercive dispute settlement, but are often reluctant to use them to promote sustainable development. These tools should be harnessed to promote SDGs. Overall, governments need to set mandatory requirements and specify clear directions for implementing the SDGs, not just "enabling" those who are already persuaded to take action (Elder & King 2018).

Private Sector

The role of the private sector is undoubtedly relevant for the bioeconomy. Firms proactively change their business processes when they experience that **pursuing** environmental and social goals can lead to cost reductions and enhance their competitive advantage; however, firms cannot address sustainability challenges on their own, joint efforts are needed to integrate environmental and social considerations into economic decisions (Niesten et al. 2017).

It might not be easy to consider sustainability within firms. As pointed out by Nawaz & Koç (2018): Although organizations and top management recognize the importance of sustainability, **the vague definition** and lack of a robust framework **impede** the management of sustainability in organizations. The operational parameters required to systematically undertake the essential elements of a

sustainability management system, and the inter-relationship of those parameters, has been largely ignored.

Civil Society

The growing **connectivity and increased availability of information** that is integral to globalization allows consumers and civil organizations to demand that their concerns and interests are incorporated into various environmental governance systems (Eakin, Rueda & Mahanti 2017)

In the context of climate change, Dale et al. (2018) found that the **active engagement of local communities** is essential for accelerating climate innovation and multilevel governance. However, despite the efforts in various spheres to involve civil society in decision making, in Europe, citizens are split on the **need to be involved** in 'decisions about science and technology' (Lovbrand et al. 2011; Upham & Dendler 2015).

Activists

Typically, Environmental Non-Governmental Organizations (ENGOs) employ the "social license to operate" (SLO) tactic to publicize a range of environmental concerns about industrial development aiming to strengthen government regulation of corporations in line with ENGOs' expressed concerns. The use of the social license tactic is thus one specific, but contemporary, expression of environmental strategies seeking greater community consultation and, ultimately, regulatory change (Murphy-Gregory 2017). An analysis of different cases in Australia showed that SLO campaigns were not primarily based upon amassing and presenting scientific evidence. Instead, they involve ENGOs strategically **employing narratives populated with emotive language in their appeals to citizens'** normative values and beliefs about large-scale corporate activity and its detrimental impact on the environment (Murphy-Gregory 2017).

There are several examples of activist campaigns where separation of the influence on corporate policies and markets and the effectiveness for environmental outcomes is required, e.g., in the case of environmental activism against palm oil in Indonesia and Malaysia, since there might be more factors for a positive environmental outcome than that of firms (Dauvergne 2017).

Academia and Research

van der Hel & Biermann (2017) focus on the material and rhetorical strategies employed by science institutions to acquire authority by fostering perceptions of salience, credibility and legitimacy among governance actors, and distinguish three modes of scientific authority:

- an **assessment-oriented** mode that combines a strategy of salience through integration, with credibility by formal mechanisms of review, and legitimacy through representation;
- an **advice-oriented** mode, which appeals to salience through the promise of independent and timely science advice, to credibility through the credentials of the scientists involved, and to legitimacy through formal recognition by governance actors; and
- a **solution-oriented** mode, with science institutions claiming relevance based on the promise to contribute to solutions for global sustainability, while credibility is sought by invoking support of the scientific community, and legitimacy through a strategy of participation.

Sectors, Products and Levels

As discussed by many authors, not only in the context of the bioeconomy but also in the SDGs, a key question is the trade-offs between the different sectors involved in bioenergy and bioeconomy. The bioeconomy includes agriculture, food and beverage production, pharmaceuticals, agro-industrial products, fisheries and aquaculture, forest logging, wood-based industries, biomass for bio-heat and

electricity production and industrial biotechnology products, such as enzymes and bioplastics (Scarlat et al. 2015). These sectors may have divergent and even competing goals so horizontal coordination beyond the "**silo**" approach is needed for good governance.

Instead of breaking them down, we need to **teach silos to dance** (Meuleman 2019). Three types of silos should be distinguished: political, mental, and institutional. However, without silos there is no focus, no structure, no accountability and no transparency. If silos need to be broken down, it should be mental silos, not institutional silos, although exceptions apply. A focus on facilitating dialogue, interaction and learning is at the core of opening mental silos.

The governance levels refer to the **geographical approach**: from the UN system, regional level, national level and subnational & local. Many potential impacts derived from the bioeconomy might be **transboundary** so global responses might be necessary: For the case of algal biofuels Benson, Kerry & Malin (2014) identify options to strengthen international agreements on related issues or the creation of entirely new global mechanisms.

Regulating extraterritorial elements can thus be problematic from a legal perspective, but such regulation is necessary to implement the proposed holistic, ecological governance approach. The topic is rather controversial, and politics and literature are divided on the matter. Some authors argue that regulators are inherently confronted with a territorial system boundary, while others argue that setting conditions to processes and production methods can be allowed, even if production occurs abroad. Similarly, it is debated whether and when unilateral action is allowed, or even compulsory, to address the transboundary problem of climate change. With regard to the latter, an important concept is that of addressing "embodied emissions" which are the sum of emissions occurring during the life-cycle of products. Subsequently, similar products can be ranked, thus allowing an informed choice on the best products or production processes (Giljam 2017).

The need to create **multi-level** governance frameworks that link institutions at different levels has been recognized in the field of the SDGs as a key issue. The European Union has been characterized as such a major supranational instance of multi-level metagovernance governing a wide range of complex and interrelated problems. However, its practice is not flawless, for example regarding the rather inflexible governance frameworks for its Cohesion Policy funding programs. Fixed frameworks ignore the different realities at different levels of administration. It may well be that at local level network governance works best, while at subnational level setting legal frameworks constitute the main rationale. From other areas there are also examples for the other way around. Therefore, the metagovernance rule "there is not a one-size-fits-all solution" also applies to multi-level governance. (Meuleman & Niestroy 2015)

As recognized for the nutrient management governance: '**top-down**' natural resource management institutions are often not well suited for local social and ecological realities, while '**bottom up**' institutions may be blind to the complex social-ecological interactions that characterize large-scale environmental systems (Ahlström & Cornell 2018). In this, the subsidiarity principle (that decisions are made at the lowest level possible) is relevant.

Polycentric governance, which involves 'many centres of decision making that are formally independent of each other' might be a possible alternative (Ahlström & Cornell 2018). International environmental law tends to be more reflexive to change than hard law, making it a desirable instrument for adaptive governance of the Earth system (Kim 2016).

Another approach refers to socio-technical systems (Bosman & Rotmans 2016):

- The niche-level at which innovative practices are developed,

- The regime-level which provides structure and stability to a system, and
- The landscape level which comprises long-term trends and exogenous events that might put pressure on the regime.

The case of forest-based bioenergy shows that an active role of municipalities and knowledge centers can foster learning processes, inclusion, and a better resolution of conflicts. On the opposite, where this role cannot be or is not accomplished, social opposition and triple bottom line unsustainability may rise. However, despite the active role of local authorities, if there is no pre-existing industrial base somewhat related to bioenergy (e.g., food industry, agriculture, forestry, sawmills, and pulp and paper), it may be complicated to carry on the transition and the delivery of sustainable outcomes (Cavicchi, Palmieri & Odaldi 2017).

Meta-Governance

Research suggests that each individual governance style has its strengths, but also its weaknesses. Typical examples from sustainability governance indicate that top-down and bottom-up initiatives are not contradictory but mutually enforcing, and that both (strong) leadership and (decentralized) ownership are needed. In terms of **governance styles**, systemic transitions often require hierarchical interventions. In any case, systemic changes require out-of-the-box thinking for which a metagovernance approach could be useful. Public managers of **successful policy programs** used three metagovernance strategies during design and management of policies (Meuleman & Niestroy 2015):

- ***Combining*** different governance approaches into arrangements of institutions, instruments, processes and actor constellations which are compatible enough with existing values and traditions to be accepted and at the same time different enough to push/pull/nudge towards change;
- ***Switching*** from one to another dominant governance style, for example when a complex and contested topic for which a network approach was designed turns into a disaster and suddenly command and control (hierarchy) is needed; and
- ***Maintenance*** of a chosen approach by, for example, protecting it against perverse/ undermining influences in the governance environment. Maintenance complements the combining and switching strategies.

> *"**Metagovernance** is a means by which to produce some degree of coordinated governance, by designing and managing sound combinations of hierarchical, market and network governance, to achieve the best possible outcomes from the viewpoint of those responsible for the performance of public-sector organizations: public managers as 'metagovernors'". (Meuleman 2019)*

Metagovernance is about combining bottom-up and top-down in productive ways; it suggests that seemingly contradictory approaches may be reconciled. It may be argued that metagovernance is a technocratic, hyper-rational approach to governance. How can a metagovernor know what is the best solution to a challenge, and doesn't metagovernance make things unnecessarily complex? An answer to the first question is that he or she does not know what is "right", because the idea that there are right and wrong answers "out there" is in contrast with the concept itself. The challenge is not about the choice between hierarchical, network and market governance in order to determine the right style, but about choosing the situationally best role for the government, taking into account the characteristics of all three governance styles. The point of meta-governance is

(a) the recognition of the strength and weaknesses of each style;

(b) taking this into account from the onset in the process of

(c) mindfully combining ideas and arrangements from different approaches.

It is grounded in existing cultures and traditions but facilitates a transformative agenda. This approach also suggests that copying standardized recipes ("best practices") could result in governance failure, whereas learning from each other (and considering translating successful practices from elsewhere) could lead to success (Meuleman & Niestroy 2015; Meuleman 2019).

Table 6 (Meta)governance principles: an overview

Metagovernance principles	Hierarchical governance principles	Network governance principles	Market governance principles
Moral responsibility and integrity	Equity (being just, impartial and fair)	Inclusiveness	Respect? Why?
Accountability	Top-down accountability	Citizens´ accountability	Outsourced/private accountability
Transparency			
Pluralism	Rule of law	Participation	Small government
Mindfulness	Transparency	Co-creation	Efficiency
Reflexivity	Reliability	Resilience	Flexibility
Long-term orientation	Chain of command	Collaboration	
Cultural sensitivity	Clear division of tasks	Non-discrimination	Empowerment
Multi-sector	Independent oversight		
Multi-actor		Multi-actor	
Multi-level	Multi-level		
Multi-perspective			
Holistic			
Knowledge-based	Authoritative	Consensual	Cost-effective
Compatibility (in relation to values/traditions)			
Redundancy			
Coherence	Coercion	Collaboration	Competition
Irony	Legitimacy	Empathy	Innovation
Additional principles for sustainable development governance			
Common but differentiated governance	Intergenerational equity	Leave no one behind	Subsidiarity

Source: Meuleman (2019)

Creating a **platform**, however, is only one aspect of landscape governance, and will only be beneficial if it forms part of a larger process of developing new institutional mechanisms for stakeholders to meet, deliberate, align discourses, and embark upon a process of shared learning (van Oosten 2013; van Oosten et al. 2014). The development of new institutional mechanisms not only relates to the process of governance, but also to the object to be governed—which is the landscape (van Oosten et al. 2014, building on Kooiman 2003, 2008).

Stringent environmental regulations may hinder economic performance and result in outsourcing to foreign suppliers with potential detrimental effects for environmental performance**.** These negative effects can be overcome by firms that invest in sustainable innovation. (Niesten et al. 2017)

Integration may necessitate **strengthening institutions** and processes that **ease coordination** across agencies and multiple levels of government. It may also require **enhancing institutions** and processes that facilitate engagement with stakeholders beyond governments, such as business and other non-state actors. However, more coordination within and engagement beyond government may not be needed for all integrated solutions. Particularly when there are already close relationships between issues and sufficient capacities to manage related interests, less coordination and engagement may save time and resources. This suggests that policymakers and researchers may want. to take a step back from advocating for multi-level, multi-stakeholder governance for all integrated solutions. Instead, such recommendations are arguably better seen as contingent, depending on the content of

the integrated solution and other factors such as the capacity of relevant agencies to coordinate different interests. The International Council for Science (2017) emphasizes the need for coherence across sectors as well as across levels and actions (transnational coherence, governance coherence, multilevel coherence, implementation coherence (Zusman & Amanuman 2018).

While the **importance of governance** and politics is recognized within various conceptual approaches to transformations, it is underdeveloped and needs greater attention (Patterson et al. 2017). Despite the importance of governance, today we are suffering a global "governance crisis": 47 % of the informed public and 57 % of the general population express distrust in government institutions (Edelman 2018).

Existing studies of private standards have recognized the increased **competition between standard-setting schemes**. Regulatory competition among private standards may not necessarily lead to negative results, such as 'a race to the bottom'. In contrast, some studies have argued that regulatory competition leads to positive effects, such as 'inducing rule convergence' or 'promoting innovative solutions'. However, in the case of sustainable biofuels, concerns on negative results from competition have been expressed in the two contexts. First, it has been widely recognized that private schemes for sustainable bioenergy vary in terms of the contents of their criteria and standards. Second and related to the point above, the private schemes differ in terms of certification procedures, costs and monitoring processes.

> *"EU regulators have failed to establish a level playing field among biofuel certification schemes. This has created opportunities for forum shopping [by private business actors] and has triggered adverse competition" (Naiki 2016).*

Meta-governance initiatives may be implementing procedural or more content-based harmonization and may be set up as permanent autonomous organizations or as temporary platforms for collaboration. They also show considerable variation with regard to the nature of the change they are trying to effect on the regulatory system and the individual standards initiatives they are meta-governing.

While meta-governance activity in the final analysis is almost always aimed at enhancing the effectiveness with which standards initiatives can improve the sustainability performance of the targeted economic sectors. This is done by boosting the gains in sustainability per certified operator or by increasing the number of certified operators – there are three more specific objectives of meta-governance that can be distinguished (Derkx 2013):

- increasing the public interest orientation of standards,
- enhancing the democratic legitimacy of standards initiatives, and
- improving the effectiveness and efficiency with which standards are implemented in
- targeted supply chains.

Box 1 The Dutch and Finnish Bioeconomy Governance approach

The governance approach in The Netherlands focusses on co-creating a long-term vision that informs for short-term action, on facilitating bottom-up regional clusters and promoting radical innovation through cooperation between vested players and frontrunners. It is a combination of a top-down and bottom-up approach, using the principles of transition management. In the Netherlands, overall, the government has a facilitating rather than a directing role. A whole network configuration has been designed and implemented and many diverse partners have been mobilized, so it all seems to be well conceptualized and thought from a transition management perspective. However, a typical Dutch danger looms here. More ambitious projects have failed in The Netherlands because they became bogged down in the typical 'clay layer' of Dutch bureaucracy and polder model, based on consensus building. There used to be a similar process, the Dutch energy transition, that started in 2001 and lasted for about 10 years. The transition project was a success in terms of networking, agenda setting, experimenting and social learning but a failure in terms of policy implementation. The whole transition project was taken over by the fossil fuel regime and all radical elements were taken out, mainly because the whole project became a serious threat to the regime. The project leader of the bioeconomy transition trajectory strongly advocated a regional approach, based on emergence and self-organization. Clear signals of scale and volume are needed, until that point the transition is still vulnerable and the whole process remains fragile.

Given Finland's biobased genes and its strong position in different biobased-related sectors, it has the potential to take a leading role in the global transition towards a bioeconomy. Finland adopts a more traditional, top-down governance strategy, focusing on the shorter-term economic opportunities and incremental innovation that keep the overall structure of existing industries intact. The government acts as director.

The current Finnish governance approach needs to be supplemented with bottom-up, strategic and network elements of a more transition-based governance approach. In Finland there is a plethora of biobased innovation projects and experiments going on, but they lack interconnectivity and coherence. To stimulate systemic change to strengthen the coherence and interconnectivity it might be helpful to create several transition pathways.

These pathways are no blueprints for a sustainable future but give direction in the transition process. They are co-created with stakeholders involved, both partners from the vested interests and emerging players. Around these coalitions and networks concrete radical innovation projects are set up (transition experiments) to create the pathways. On top of already chosen areas for the Finnish Bioeconomy Strategy, we have identified four different pathways that seem worthwhile for exploring further based on the competencies of the Finnish economy and the position in the biomass value pyramid. To get a leading position worldwide, a more advanced and sophisticated governance strategy is needed.

The Dutch government acts as a facilitator, while the Finnish government acts more as a director of the transition. We recommend that Finland's governance for the bioeconomy be improved by applying insights from transition management, while the Dutch approach runs the risk of being captured by vested interests.

Source: Bosman & Rotmans (2016)

Box 2 Regional sustainability networks in the Netherlands

The national 'Duurzaam Door' (Moving Forward Sustainably) Policy Programme (2014-2017) regards these networks as generative governance arrangements where new knowledge, actions and relations can co-evolve together with new insights in governance and learning within sustainability transitions. It focuses on the capacity building for organizational and societal learning in and through local and regional networks. The program therefore connects with the dreams of the people in place based sustainability networks, working for circular economy and new value streams (e.g. chains that create value other than material or monetary ones).

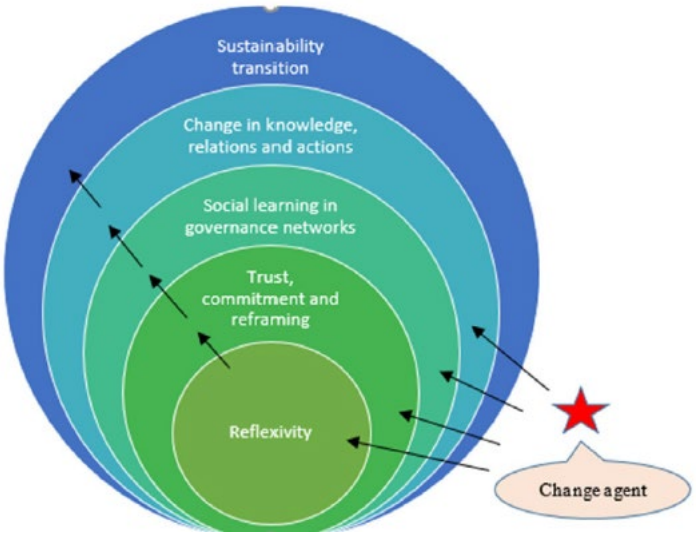
These networks can be regarded as social transition arenas where uncertainty is faced and challenged. We found that reflexivity fosters to the emergence of trust, commitment, and reframing. In turn, the case studies also suggested that reflexivity can be an outcome of social learning. Additionally, we found that trust, commitment, and reframing evolved together as they seemingly interact and influence each other. Higher trust was found together with higher commitment and higher reframing activity in all three regional networks.

Reflexive turns involve a certain change in network perception or action. Reflexive turns can be a reaction to a threat, such as the falling apart of the network, or the missing of funding possibilities. On the one hand, the results showed that there was a trigger to become reflexive. On the other hand, we found reasoning and tendencies to be non-reflexive, such as possible attachments to the past, tendencies 'to fight for what we have'. Still, the social learning can be regarded as less democratic than expected. Also, we can see here that social learning cannot be seen in a vacuum, and therefore is a vulnerable activity.

These findings need to be approached with some caution; whether effective social learning contributes to effective governance networks with agency (Grin et al. 2010) - let alone sustainability transitions (Rotmans & Loorbach 2006) - are yet topics for further research.

The present study suggests that knowledge, relations, and actions, as outcomes of social learning processes in a governance network, are relatively more salient and explicit than trust, commitment, and reframing.

Figure 10 Analytical framework: relations between the concepts



Source: Sol et al. (2017)

As an example of the different visions, Table 7 summarizes key characteristics of the Dutch Biobased Economy and the Finnish Bioeconomy Transitions.

Table 7 Comparing Dutch Biobased Economy and Finnish Bioeconomy Transitions

	Dutch Biobased Economy	Finnish Bioeconomy
Transition	Fossil to biobased	Bulk to specialty
Drivers	Chemistry sector/government	Innovation in genes
Urgency	Rather high	Average
Phase	Pre-development	Just before take-off
Regime	Economic top sectors	Powerful silo structure
Niches	Systematic experimentation	Many unconnected pilots
Vision	Co-created vision for 2050	Government-led vision for 2025
Scale	Regional	National
Approach	Conceptual, network-based	Practical, sector-based
Focus	Radical innovation	Incremental innovation

Source: Bosman & Rotmans (2016)