Global Bioeconomy Summit
Conference Report

Innovation in the Global Bioeconomy for Sustainable and Inclusive Transformation and Wellbeing

Bioökonomierat

SUPPORTED BY:
Federal Ministry of Education and Research

Content

Executive Summary

About the Global Bioeconomy Summit 2018

Around 700 high-ranking representatives from politics, science, civil society and the business sector and from more than 70 countries met in Berlin from 19–20 April to discuss the latest developments and challenges in the global bioeconomy. This was the second time that the German Bioeconomy Council had organized the Global Bioeconomy Summit in the German capital.

More than 100 top-class speakers contributed to the event. They included ministers and government representatives from Asia, Africa, Europe, South and North America; international policy experts from the United Nations, the Organisation for Economic Co-operation and Development and the European Commission; as well as high-level representatives from science and industry. In six plenary sessions, the participants discussed emerging trends in bioeconomy policy and international collaboration, specifically with a view to sustainable development, nature conservation and ethics as well as to bio-innovation and digitalization.

The GBS2018 further defined a set of 14 themes of global relevance for bioeconomy research and policy agendas. While some of these key themes relate to discussions continued from GBS2015, others are newly emerging topics, particularly: a) the links between climate change, health impacts and bioeconomy, b) digitalization and converging technologies in the bioeconomy c) communication and trust in transformative sciences & technologies, d) interdisciplinary education and training at all levels in bioeconomy, e) biodiversity as a resource and foundation for bioeconomy, f) sea and ocean bioeconomy g) innovative ways of financing and h) bioeconomy in the cities or “biocities”.

Throughout the meeting, the participants made it clear that while bioeconomy initiatives around the world seek to contribute to sustainable development, bioeconomy has yet to be appropriately included in international policy fora discussing innovation, climate action, biodiversity conservation and sustainable development.

At the end of the 2-day conference, the 40 members of the Summit’s International Advisory Council recommended setting up a more formalized international mechanism or forum to support and promote:

- a structured exchange of policies and practices among the global bioeconomy community on the key themes identified by the GBS2018
- a state-of-the-art knowledge base for bioeconomy policy and governance, specifically of evidence-based information and assessments that are considered trustworthy by all stakeholders
- a competent and significant bioeconomy voice in global policy fora related to innovation, sustainable development and the Paris Agreement, providing a holistic perspective and considering the interdependencies between individual SDGs in the bioeconomy
- the facilitation of international collaboration programs in bioeconomy R&D and capacity building oriented toward common goals

Globally, 50 countries have issued policy strategies related to bioeconomy development. Yet the potential of the bioeconomy is rarely discussed in international policy fora. The GBS made it clear that we need a continued and, ideally, a more formalized international exchange on bioeconomy policy and practices. The Global Bioeconomy Summit has created a good basis for such a multilateral and inter-disciplinary dialogue.

Berlin, 15th July 2018

Prof. Dr. Joachim von Braun Prof. Dr. Christine Lang

Chairs of the German Bioeconomy Council

Political Welcome Address

Federal Minister of Education and Research of Germany

Anja Karliczek, MdB
Federal Minister of Education and Research

Your Excellencies, Ladies and Gentlemen,

How can we use natural resources without depleting them entirely? This is one of the great challenges facing mankind. And it is not new. In Germany, the basic principle of sustainability was already laid down in writing almost 600 years ago – in 1442 in the Forest Regulation of the Bishopric of Speyer. The aim was to protect wood as a natural resource which was becoming increasingly scarce. Even then, those responsible realized that they could not use more of this valuable resource than could grow back. This rule still applies to our ever-scarcer resources today.

In obeying it we are following nature's example. Nature has created an almost perfect cycle, which allows everything to thrive. We are using this cycle in the bioeconomy – every country in its own way. We will be talking about the different approaches in different countries here in Berlin today. I am delighted to welcome you to the second Global Bioeconomy Summit. We are here today because we know how important the bioeconomy is for our future and because we appreciate the opportunities it offers us.

A further seven countries – including France, Italy and Thailand – have introduced ambitious bioeconomy strategies since the first Bioeconomy Summit was held in November 2015. This means that almost fifty states have placed this topic on their political agendas. I am delighted with this dynamic development. We must continue along these lines in future.

Human society is living beyond its means. Emissions of harmful greenhouse gases, shortages of raw materials, increasing environmental pollution, water scarcity, species extinction – the list of urgent challenges is long. We need to find solutions to enable our continued co-existence and economic activities on this planet. The bioeconomy

presents huge opportunities. The enormous progress made in the life sciences combined with the introduction of digital and other technologies is providing us with new tools which we would never have dreamt of only a few decades ago. New products and processes are emerging as we combine innovations from different fields.

It is our task to make wise and efficient use of these opportunities in order to reach our goal of a bio-based, sustainable economy which follows natural cycles and material flows. This form of economic activity can make a huge contribution to mastering the challenges of the 21st century – ranging from scarce resources to ongoing climate change and food security. We can also use our new biological knowledge in the fight against major common diseases.

We are, of course, aware that the bioeconomy will not sell itself. It will not simply fall into our laps, nor can it be decreed from above. It is a societal transition process which will need time.

Ladies and Gentlemen,

I would like to explain three principles of the bioeconomy:

1. *The bioeconomy is local, but must also think globally.*
2. *International cooperation is an absolute must for the bioeconomy.*
3. *Research and development are the basis for the proposed transition process on the road to the bioeconomy.*

Of course, there is no "single" right road to the bioeconomy. To quote the saying: "All roads lead to Rome." Different regions may have different biological resources or be strong in different research and technology sectors, depending on local conditions. The bioeconomy will therefore always demonstrate different characteristics. Some countries will make predominant use of agriculture – others of forests or marine resources.

But even if the bioeconomy is regional – and this is where I come to my first point – we must think globally.

Our traditional production chains and trade routes are networked globally. And we must network the value chains of the bioeconomy accordingly. It is a matter of establishing new value creation paths. What used to be waste materials from the production of one product will in future be valuable raw materials for other products. Rapeseed oil is just one example: The press residues used to end up as waste but it is now possible to isolate valuable proteins which serve as the basis for innovative basic materials or additives in paints, cleaning agents, building materials and lubricants. My Ministry is funding a research alliance working in this area. And this is just one of many examples. We must combine these strengths with strengths in other regions. Only if they are perfectly matched will we be able to score the best results globally – for the sake of both society and sustainability. I now come to my second point.

We can only exploit the full potential of the bioeconomy through close cooperation. Ladies and Gentlemen, the fact that you have come to Berlin today shows that you are all aware of the importance of international exchanges and networking. The Bioeconomy Summit really deserves to be called "global": Two-thirds of the more than 800 registered participants are from abroad. They represent over seventy countries. Many other people will be following the discussions via live webcasts. This provides a good starting point for taking a further step on the road to an "international bioeconomy agenda".

We have ambitious aims. Take, for example, the question of ensuring global food security, for which we all share responsibility. We must take a look at all the facets of this problem if we are to succeed. We must improve our knowledge about soils, intensify crop and plant breeding, design our agricultural systems to be sustainable – and much more besides. But we can only do so by pulling in the same direction. Our research and activities must be open to all technologies.

There is still plenty of unexploited, undreamed-of potential for a sustainable, bio-based economy. The question is: How can we uncover and make use of these opportunities?

This is where my third point comes in: A key factor in this context is research and development. After all, we can only optimize and fully exploit those biological processes and relationships which we understand.

Germany has long been active on a big scale in funding research into the bioeconomy. It was one of the first countries with a dedicated bioeconomy research strategy – the National Research Strategy BioEconomy 2030, published in 2010. This strategy includes systemic approaches alongside traditional biotechnology research. It is not only a question of technological developments such as resistant seed varieties, robust crop plants, new enzymes for biobased industry or new biorefinery approaches. Findings in the social sciences and political and economic research are just as important. These findings teach us how the transition process can succeed, what societal effects it will have, what types of infrastructure will be needed – and much more besides.

Systemic approaches have one disadvantage compared with technological approaches – they are rarely studied by commercial companies. This means that the onus is on governments. Germany has been promoting research into the social, political and economic aspects of the bioeconomy since 2014 under its "Bioeconomy as Societal Change" programme. The Federal Government is currently introducing bioeconomy monitoring as part of this programme. This is important in order to be able to determine whether we are on the right path or whether we need to correct our course.

After all the bioeconomy is like so many other areas in life: Good intentions are not always enough. The bio-based economy will involve complex, sometimes unintentional and unforeseen interactions, which do not stop at national borders. Some such developments are already becoming apparent, others will emerge in the course of time.

Ladies and Gentlemen, you will have an opportunity to discuss these questions and exchange ideas with Stefan Bringezu and Pedro Machado later.

The Federal Government intends to continue along the path it has chosen for the transition to the bioeconomy. As part of our strategy, we will be publishing the second round of our "Tailor-made bio-based ingredients for a competitive bioeconomy" funding measure today. In doing so, we want to encourage research and development projects aimed at innovations in the field of tailor-made bio-based products – ranging from the original idea, to proof of feasibility through to experimental development.

We are continuing to consistently develop the National Research Strategy BioEconomy 2030. As part of this effort, we have had external evaluators assess our research funding over the last six years – with a very positive result.

However: We are aware that such massive changes to the economy can only succeed if we have society on our side. We must talk to key stakeholders and representatives of civil society. We will be doing so in the summer. But there is still more to do. The next step is to draw up an interdepartmental Federal Government agenda – "From Biology to Innovation" – in collaboration with science, industry and civil society. Our aim is to step up efforts

to integrate the potential of biological knowledge and biotechnological processes in all areas of life and the economy. This interdepartmental agenda will provide the bioeconomy with a new political framework.

Research is a major key to the bioeconomy – but evaluating research results and applying these results through relevant policies is essentially a societal and political task – not just at regional or national level but also at international level. This is particularly true with regard to the bioeconomy and calls for continuous coordination and discussion.

The two summits on the bioeconomy – the Global Bioeconomy Summit 2015 and tomorrow's event – provide a sound basis for an international exchange. We must now work together to ensure that the bioeconomy is given a more prominent place on the international political agenda, for example at meetings of the G7 and G20. It is up to all of us to support this topic and lend it substance.

We also owe the fact that we are meeting here today to the German Bioeconomy Council, the Federal Government's independent advisory body on the bioeconomy. I would like to thank all the members of the Council for their great commitment to the bioeconomy and for organizing today's summit. Germany is pleased to host the Global Bioeconomy Summit.

I am delighted that you are all here today. I wish you good talks and hope that your interaction in research and economic policy will provide a contribution to world peace.

Political Welcome Address

Federal Minister of Food and Agriculture of Germany

Julia Klöckner, MdB
Federal Minister of Food and Agriculture

Salutation

I am impressed by the many bright minds and skilled experts from all over the world who have gathered here in Berlin for the second Global Bioeconomy Summit!
I am delighted that you have accepted the invitation from the Bioeconomy Council and the Federal Ministry of Education and Research. Bioeconomy is one of the most exciting issues of our times. Bioeconomy will define our future. We are aiming at nothing less than replacing fossil resources with renewables. In our everyday life, in business, in technology. One example is a detergent that saves resources in two different ways:

1) Petroleum-based surfactants can be substituted with bio-based surfactants
2) the detergent is much more efficient because it can be used at lower temperatures which saves energy!

Another example comes from the field of engineering, more specifically tunnel construction: A starch-based renewable material optimises concrete in such a way that it sticks much better when sprayed onto tunnel walls. This process saves time and material while also improving working conditions. The bioeconomy also opens up new prospects for our agricultural and forestry sector. While we have to import fossil resources, renewables grow right on our doorstep and generate new sources of income for our agricultural and forestry sector.

Ladies and Gentlemen: There are sound economic arguments for investing in bioeconomy. And more still: We have set ourselves the goal to lead a lifestyle that does not compromise the life of future generations. Our children and grand-children will benefit from each barrel of crude oil that is replaced by renewables, and from each square metre of habitat that we conserve. This is a call for joint action.

In German we have a saying to express something being of no importance whatsoever. You say that something is as important as if a bag of rice in China fell over. This saying is completely outdated. If something happens anywhere in the world today, it should concern us as much as if it happened in our own neighbourhood.

For Germany this means that
- *we have to wean ourselves off fossil resources*
- *we always have to bear in mind climate change mitigation and environmental protection*
- *we have to strive towards reaching the SDGs, the Sustainable Development Goals to which we have committed ourselves.*

How can we do this?

Ladies and Gentlemen, the Federal Government has set out a bioeconomy strategy in order to jointly develop ideas for a path towards an increasingly bio-based economy. We have set ourselves the task of always taking into account the bioeconomy, be it in day-to-day life, in society or in business. We are investing heavily to achieve this task: My ministry is supporting applied research; the "Renewable Resources Funding Programme" alone is being financed with more than EUR 60 million.

The research carried out as part of the programme is truly hands-on:
- *One example is how the characteristics of plants that supply renewable resources can be further refined.*
- *Another example is how residual matter that is discarded during production can be reused even more effectively.*
- *The development of bio-based insulating materials for housing construction is another area of research.*

My Federal Ministry of Food and Agriculture is orchestrating the different strategies with the aim of establishing a policy framework. Other ministries have numerous specific measures, too.

Currently, we are working with the Federal Ministry of Education and Research and the Federal Ministry for Economic Affairs and Energy on how to measure the bioeconomy share of our economy – we want to establish a monitoring system so we can show where we stand. This monitoring system will also facilitate comparison at global level.

Our aim is clear: We want to master the transition towards a more bio-based economy in order to protect our environment and benefit future generations.

Ladies and Gentlemen, international trade routes, tourism, flexible lifestyles and working environments – we are becoming ever more global. We are turning into truly global citizens. Global citizens who are committed to their home country and to the international community alike. That is why I am very much delighted, Ms Semedo, that you have come to Berlin in your capacity as Deputy Director-General of the FAO.

I am also delighted that you, Professor Töpfer, as former Executive Director of the UN Environment Programme, are here today. The FAO, as part of the UN, is a global knowledge organisation – it is, so to speak, the brain that is working across the globe to strengthen the agricultural, forestry and fisheries sector and to enhance food security. The Federal Ministry of Food and Agriculture is a vital strategic partner at the side of the FAO and will continue to be so. We are working closely and successfully with the FAO in the area of bioeconomy. With financial support from my ministry, the FAO has established an expert panel composed of a diverse range of governments and NGOs. The panel gathers ideas and policies from around 20 countries and drafts guidelines. These serve as a road map to generate bioenergy while protecting food security – and to support other countries and regions in drawing up their own bioeconomy strategies.

Ms Semedo, I wholeheartedly agree with you in that it is key to harness the bioeconomy in order to reach the joint goal of food security. And no one can tread this path towards a bio-based economy alone. No single country can manage this alone, we all have to work in concert.

Dear conference participants, at this forum you will discuss our natural habitat, clean air, clean water and food security. Each and every one of you has come to this forum with award-winning ideas on bioeconomy – I hope that you will pick up as many new thoughts and ideas to take home with you. I also hope you that you can apply your knowledge so that we can all contribute to the careful stewardship and sustainable management of our resources.

Welcome Address

Maria Helena Semedo, Deputy Director-General, Food and Agriculture Organization of the United Nations

Your Excellency, Julia Klöckner, Federal Minister for Food and Agriculture,
Honorable Ministers and Ambassadors,
Distinguished Delegates,
Ladies and Gentlemen,

On behalf of Mr Graziano Da Silva, Director-General of the Food and Agriculture Organization of the United Nations, I would like to thank the German Government and the City of Berlin for again inviting me to this excellent platform on bioeconomy.

Since the last Summit in 2015, major global developments – such as the 2030 Agenda for Sustainable Development and the Paris Agreement – have been shaping decisions and actions of the international community. Today, more than ever, we are facing a more complex world, calling for bolder responses and actions at all levels. All of us have a role to play: the UN, Governments, the private sector, NGOs, civil society, research and others. From climate change to poverty, today's challenges call for holistic, cross-cutting and inclusive solutions, like sustainable bioeconomy. Therefore, I am pleased to note that since 2015 about 50 countries worldwide have created policy strategies related to bioeconomy development.

Ladies and gentlemen,

Let me share some key points:
First, sustainable bioeconomy is foremost about nature and the people who take care of – produce – and use biomass. Family farmers represent a major asset for sustainable bioeconomy development – not only as producers of biomass, but also as holders of important knowledge on how to manage natural resources in a sustainable way.

Second, achieving sustainable bioeconomy is complex. We should not oversimplify bioeconomy development, this can have risks and be counterproductive. We all agree that food security is a priority. It is not just about food production – if is often about lack of access to food. In fact, we produce enough food to feed the planet. Bioeconomy can improve access to food, such as through additional income from the sale of bioproducts. Or consider climate change. Just because a product is labelled bio does not mean it is good for climate change, it depends on how it is produced, and in particular on how much and what type of energy is used in the process.

And my third point is that we should ensure that all relevant knowledge – traditional and new – is equally important in bioeconomy and should be equally shared and supported. Innovation plays a key role – it is about new technologies, but also new way to better support existing ones– and it needs to be contextualized.

My fourth point: FAO agrees with the recommendation of the 2015 Summit on the "need to establish an international forum for bioeconomy as an informal network to foster strategic dialogue with policymakers, private sector, civil society and scientists".

Ladies and Gentlemen,

Let me share with you what FAO can offer to promote sustainable bioeconomy. We work across the conventional bioeconomy sectors – agriculture, forestry and fisheries, but also on technologies relevant to bioeconomy, like information technology and biotechnology – with emphasis on small-holder biomass producers.

We support FAO Member States with our vast technical expertise and know-how on the sustainable production of food and non-food goods. At the same time, we promote strategic partnerships with civil society, the private sector and research

institutes. FAO's role as a global neutral forum to discuss complex and sensitive bioeconomy topics such as bioenergy and biotechnology is widely recognized. We also promote traditional and new knowledge and technology, such as the Globally Important Agricultural Heritage Systems – they represent agricultural Knowledge forged over centuries. We now have 50 sites in 20 countries.

On the other hand, in November 2018, we will be hosting the 1st International Symposium on Innovation for Smallholders and Family Farmers.

Earlier this month we concluded the 2nd International Symposium on Agroecology in the context of SDGs, which endorsed an Initiative to scale up agroecology.

In addition, thanks to the generous support of the Government of Germany, we are currently developing sustainable bioeconomy guidelines with the support of a multistakeholder international sustainable bioeconomy working group. In that context, we have identified 25 cases from around the world that serve as successful bioeconomy examples to develop good practices. For instance, a group of women fishers in Zanzibar are producing cosmetics from algae, opening up a whole new market for niche products. In Malaysia there is a government programme supporting community-based bioeconomy. And in Colombia, an entire community participates in a project that transforms pineapple husk into biodegradable packaging.

Ladies and Gentlemen,

In conclusion, we know the challenges of sustainable bioeconomy – and collectively – we already hold solutions to address them. By this, I mean that we produce sufficient food to address hunger, and we have knowledge, tools and approaches to produce and use biomass in a sustainable way. But we need to bring this together with the appropriate enabling environment, including policies, institutions, capacities, good governance and financial support. To do so, we must foster internationally-coordinated efforts and ensure multi-stakeholder engagement at local, national and global levels. This calls for measurable targets, means to fulfill them and cost effective ways to measure progress. FAO is already moving ahead in the global development of sustainable bioeconomy and stands ready to continue to do so.

Together, let's harness the development for sustainable bioeconomy for all and leave no one behind.

Thank you for your attention.

Reports on the Plenary Sessions

Plenary Session I:

Revisiting the Concept of Bioeconomy

Strategic Debate:

- Chairs: Christine Lang & Joachim von Braun, Co-Chairs, German Bioeconomy Council
- Ruben Echeverria, Director General, International Center for Tropical Agriculture (CIAT)
- H. E. Ameenah Gurib-Fakim, Former President, Mauritius
- Yin Li, Deputy Director-General of Bureau of International Cooperation, CAS

Keynote Session:

- Christian Patermann, International Bioeconomy Advisor

Given the packed program of the GBS2018, Joachim von Braun and Christine Lang jumped straight into the first plenary session they chaired, entitled: “Setting the Scene”.

At the beginning of 2018, almost 50 countries had incorporated the promotion of the bioeconomy into their national policy strategies. Seven of these countries joined the group in the last two years. In accordance with the global perspective the summit embodied and propagated, the international panelists all advocated more communication and collaboration between the nations and their representatives. **Ruben Echeverria** made the point that once communication is established, it is important to move quickly from strategy documents to action in order to facilitate the transition to a sustainable bioeconomy. **Yin Li** pointed out the enormous industrial and financial potential of a biobased economy. China expects the bioeconomy to be one of its leading industries by the year 2020 with a net worth of about 1,600 billion USD. However, Li also pointed out that society has to change for these numbers to become reality. The need for a mindset transformation was also highlighted by **Ameenah Gurib-Fakim**, who stressed that people need to better understand the intrinsic value of biodiversity. Its impact on the many invisible aspects of life, such as regulation of the water cycle, is especially crucial to our survival. Gurib-Fakim also pointed out that biological knowledge will be the key to discovering and using new materials and pathways.

In summary, the panelists stressed the importance of societal transformation. Public R&D funding and capacity building were considered vital for enabling innovations to achieve many of the Sustainable Development Goals, specifically nature and biodiversity protection, inclusive economic growth and wellbeing for all. The panelists called for more multilateral collaboration on equal terms, especially between industrial and developing nations, in order to create a sustainable and inclusive bioeconomy. In the transition process, education will play a major role in motivating entrepreneurial innovation as well as social and cultural change. However, national and international policy incentives are needed in order to nudge industry towards a sustainable bioeconomy.

Christian Patermann highlighted the emerging trends in the global bioeconomy. He named both the changing educational demands as well as the increasing cross-border collaboration between regions, countries or even continents as two of the most recent and most important developments. He also pointed out that the specific features of bioeconomy, such as circularity, health benefits and functionality, especially through biodiversity, had all finally moved into the limelight as emerging trends of the global bioeconomy. Finally, Patermann also stressed that bioeconomy innovation might be greatly leveraged by the imminent digitalization of our lives and industries, for example by advances in artificial intelligence and synthetic biology. He encouraged the audience to be at the forefront of these new developments.

Plenary Session II:

Bioeconomy, Nature & Sustainable Development

Keynote Session:

› Chair: Jussi Manninen, Executive Vice President, VTT Finland

1. John Schramski, Professor, University of Georgia
2. H. E. Ameenah Gurib-Fakim, Former President, Mauritius
3. H. E. Tarsicio Granizo, Minister of Environment, Ecuador
4. Mauricio Lopes, President, Brazilian Agricultural Research Corporation (Embrapa)

Strategic Debate:

› Chair: Dieter Birnbacher, Professor, Heinrich-Heine-University Düsseldorf
› Hiroaki Ishizuka, Chairman, Japan Bioplastics Association
› Maritta Koch-Weser, Founder and President, Earth3000
› Jean-Francois Soussana, Vice-President International Policy, INRA
› Maarten van Dijk, CEO, SkyNRG

The second plenary session tackled the complex interrelations between bioeconomy, nature, and sustainable development. In his introductory keynote lecture, **John Schramski** used a battery model to demonstrate that in the past 100 years humans have converted and used up large proportions of the terrestrial energy stores which were built up over a period of 400 million years in the form of plants, animals and fossil fuels. Exponential consumption of fossil fuels and natural resources (the “great acceleration”) has led to the battery being rapidly depleted and the first signs of the biosphere’s instability are being observed. It is therefore not enough to use more renewable energy and bio-resources instead of fossil fuels. “Humanity needs to slow down”, to change lifestyles and specifically the curves of resource consumption.

Ameenah Gurib-Fakim pointed out that man-made climate change had already caused an immense loss of biodiversity, especially in Africa where species are disappearing at almost twice the global rate. This loss of biodiversity in turn causes economic loss – an estimated 3% of Africa’s GDP by the year 2050. Sustainable development and agriculture would help to counteract this loss. However, according to Gurib-Fakim, the necessary tools, such as education, knowledge transfer, and training, are also severely underdeveloped in Africa.

H. E. Tarsicio Granizo observes a changing mindset in his country and worldwide towards a “conscious citizen paradigm” which embodies ethical and sustainable consumption of resources. Particularly with regard to dependency on oil and mining, he said humanity needed to strive towards more sustainable alternatives. He recommended using biological resources and knowledge to change the (global) production matrix.

With regard to food security, depletion of soil fertility and biodiversity losses in many countries, **Mauricio Lopes** introduced a new concept developed in Brazil that could prove vital for a circular and sustainable bioeconomy: he suggested integrating crops, livestock and forestry on the same area of land in order to produce carbon-neutral beef, milk or fish. According to Lopes, by using specific tools, knowledge and creativity, any given area of land could be sustainably used to its maximum, helping to achieve the SDGs while still leaving large enough parts of the country and nature untouched in order to preserve biodiversity.

The subsequent **strategic debate "Ethics of Actions for Sustainability"** was guided by **Dieter Birnbacher** who pointed out that, with the Brundtland definition, sustainability had become a very ambitious and ethical concept, however with a strong anthropocentric perspective as it was mainly dealing with human needs. The other notion relevant for the discussion was nature. He saw a growing public concern relating to different kinds of values and ideals which are relevant for bioeconomy, for example the loss in biodiversity as a result of agricultural intensification, or animal welfare in intensive livestock farming. In view of population growth and climate change, **Jean-Francois Soussana** urged a move beyond conserving the status quo to a more proactive vision, such as restoring ecosystems and soils and recapturing atmospheric carbon dioxide. The bioeconomy can contribute to such proactive solutions, e. g. by enabling agricultural efficiency gains, realizing the use of circular and cascading resources, and by developing new landscapes that mitigate climate change while providing food and ecosystem services. Technological and engineering solutions will be required to achieve such results; however, they usually also involve problems for stakeholders and nature. Considering humanity as part of nature, there is a need to engage in dialogue and provide interdisciplinary scientific evidence to actively manage these problems.

Taking Japan as the example, **Hiroaki Ishizuka** stressed that even in recent history humanity had responded to challenging crises and disasters with new solutions. He said a cooperative approach between academia, industry and government was needed to achieve the aim of conscious industries and societies who live in harmony with nature and achieve the SDGs. Industry would have the role of providing financing and environmentally benign products at least cost. Academia would provide education, training and scientific research, while government would set the overall policy framework. Societal success depends on whether such biobased products satisfy people's needs at a reasonable cost.

Maritta Koch-Weser spoke from the perspective of NGOs concerned with nature conservation. She saw tremendous opportunities in developing a sustainable bioeconomy because it could add value to maintaining forests and healthy natural resources instead of exploiting them. Bioeconomy R&D was also important for indigenous people and traditional knowledge systems. However, bioeconomy would need to address social justice, especially when trading biological resources and knowledge from indigenous people. With a view to sustainability, NGOs call for firm, transparent and enforceable rules in bioeconomy. However they must also be concerned about missed opportunities of not exploring bioeconomy innovation. The NGOs' contribution to developing a sustainable bioeconomy was to advocate rules-based processes, provide watchdog functions while legislation is being drafted, provide legal advice and defense in the fields of nature conservation, but also to foster knowledge, transparency and competency. NGOs should promote systems that will give rise to trained and specialized local lawyers, consultants, investors and banks.

Finally, in terms of new and concrete actions for sustainability, **Maarten van Dijk** drew attention to climate action in the aviation industry where there is a great need to find low-carbon solutions. Aviation growth is outpacing the "great acceleration" curves. It is estimated that about 500 million tons of fuel are needed. Flying less and further gains in fuel efficiency are required, but alternative fuels will still be needed for at least 30 years with the planes in service today. He encouraged the audience to collaborate on the topic of sustainable biofuels for the aviation industry.

Plenary Session III:

Innovation Impetus – the Future of Bioeconomy

Keynote Session:

- Chair: Murray McLaughlin, Co-Chair, Government's Industrial Bioproducts Value Chain Roundtable, Canada

1. Ian Goldin, Director, Oxford Martin Program on Technological and Economic Change
2. Juan Carlos Castilla-Rubio, Chairman, Space Time Ventures
3. Navi Radjou, Author and Strategist
4. Rob Carlson, Managing Director, Bioeconomy Capital

Strategic Debate:

- Chairs: Jim Philp, Policy Analyst, OECD & Newai Gebre-ab, former Chief Economic Advisor to the Prime Minister of Ethiopia
- Jennifer Molloy, Researcher, University of Cambridge
- Adrian Percy, Global Head of Research & Development, Bayer Crop Sciences
- Alix Zwane, CEO, Global Innovation Fund

The introductory keynote on "Economics of Transformation in the Anthropocene" **Ian Goldin** pointed out that mankind was currently in the middle of a massive transformation driven by population growth and ageing, an explosion of the middle class and resource consumption, hyper-connectivity, digitalization, and a super-exponential speed in technological developments, such as genomics. These changes brought enormous good but also entailed great risks. There was a widening disconnect between market forces and the consumption choices they form, on the one hand, and the needs of the planet and of prioritizing people, on the other hand. Due to market failure to provide the necessary signals to discipline our freedoms, Ian Goldin called for more active countries, regulations and control to manage the planet's common resources. International institutions, especially the financial institutions, had failed to manage the process and to define ethical criteria. Goldin encouraged the audience to take action, saying that conditions were favorable: powerful technologies, science-driven policies, and an ever-growing pool of talented and diverse people.

Juan Carlos Castilla-Rubio highlighted the value of nature and biodiversity as inspiration for new innovations. He reported that a global industry worth USD 4 trillion annually had arisen from understanding and being aware of a mere 0.1% of life on the planet. Many times, however, none of the benefits gained from discovery and subsequent application made it back to the country of origin. Castilla-Rubio had therefore introduced the Earth Biogenome Project, which aims to sequence the genome of all eukaryotes on the planet – starting with the ones living in the Amazon basin. People living there would ideally be custodians of a par-

ticular wealth of biodiversity for which they could be compensated. The ambitious project is funded with USD 4.8 billion over the next ten years and could create a wealth of vital new biological knowledge. In a separate project, a team is working to encrypt the resulting genomic information using blockchain technology with the aim of enabling transparent and fair knowledge transfer in the bioeconomy. Companies and research institutes would receive access to the knowledge and local communities would be compensated by a sort of usage fee.

Navi Radjou introduced the audience to the concept of "Frugal Innovation". Scarcity can be a great motivator and opportunity for bio-innovation which responds to vital needs, is inclusive and also provides solutions for vulnerable and low-income communities. Quoting Gandhi: "There is enough for everyone's need but not for everybody's greed." Radjou called for a renunciation of the self-centered, unsatisfiable consumer ideals and a transition to a conscious society based on unity with nature, ingenuity, wisdom, and compassion.
Rob Carlson highlighted the economic development and the opportunities linked to advances in biotechnology and bio-innovation. Biotechnology and bioeconomy were already significant players in the global economic market today but the untapped potential of many innovative biobased products was huge and the market was expected to grow. During the financial crisis some ten years ago, the biotechnology sector had been the only one that remained stable and failed to crumble.

The subsequent **strategic debate** revolved around several important questions: First, the session chairs **Jim Philip** and **Newai Gebre-ab** wanted to know, what would be the driving force for innovation – would market demands and societal expectations "pull" innovations into existence, or would science and technology "push" them out? The panelists agreed that there would not be one driving factor; all of them acknowledged that both factors would be essential. The societal and market demands for innovation would ultimately influence policies and back-up funding, which would be allocated to researchers and engineers, would drive their output.

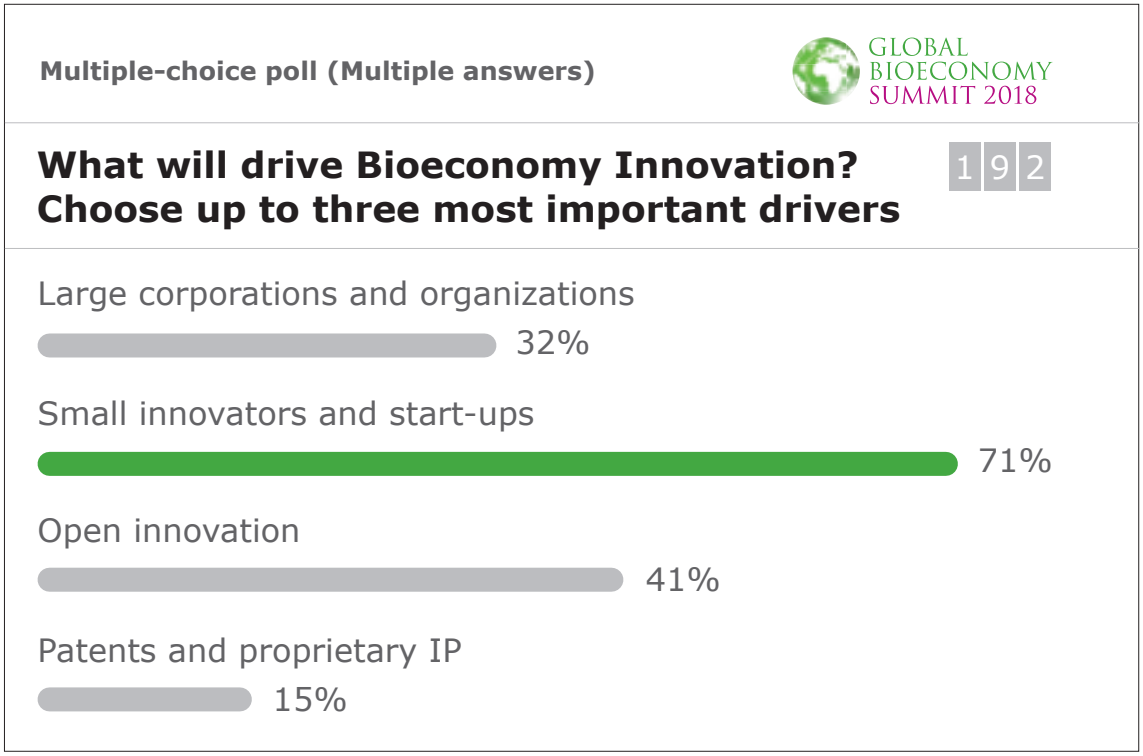
Alix Zwane pointed out that already today traditional venture capitalists and innovative philanthropy supported great bioeconomy innovations, however public funds were absolutely critical. The markets were not always able to balance and tolerate the risks in pursuit of social value. In future, different kinds of capital needed to be pooled and blended together, e. g. debt investments denominated in local currencies. With a view to risk sharing, policy might also consider rewarding outputs instead of subsidizing business activities, e. g. by using prices or minimum volume guarantees. **Jennifer Molloy** stressed another important role of the public sector. Certain policies and regulations needed to be updated and changed ahead of scientific input or societal demands in order to foster, rather than hinder, the translation and implementation of advances in science and technology.

Next, the panelists debated whether large established companies or small startups would be the key innovators of the future. In a poll, the audience clearly expected the bioeconomy to be driven by small innovators and startups. **Adrian Percy** represented one of the global corporate players in agricultural R&D but he also saw an important role for the increasing activities emerging from bottom-up innovation, resulting, for example, from citizen science and the "democratization" of science, where research and its tools have become much more accessible to many people. Session chair **Jim Philip** thought that a bigger concern might be how to help startups take the plunge towards becoming medium-sized companies.

The next question dealt with whether open source approaches or patents would drive the future of bioeconomy. The audience rated open innovation as important driver, while patents and proprietary IP were considered less pertinent. The panelists actually saw room for both. While the open source approach can be a strategy for growing the market quickly, as **Jennifer Molloy** pointed out using the example of Tesla, patents were also considered necessary for providing a return on investment and a basis for further financing.

Finally, the panelists addressed the question of risk perception and fear of the unknown consequences of innovations across the bioeconomy sector. **Jennifer Molloy** pointed out that risk perception was always coupled with perceived benefits and colored by personal experiences. Perception also varied depending on availability of information. **Adrian Percy** noted that public perception could significantly influence policies which ultimately translated into regulations. In order to balance perceptions, the public should be made aware of the opportunities and risks of new technologies but also of the consequences and missed opportunities of not using and developing them. **Zwane** added that successful innovations were those that responded to people's needs.

Figure 1: Slido audience poll



Plenary Session IV:

Global Policy Frameworks for the Bioeconomy

Keynote Session:

› Chair: Regina Birner, Member, German Bioeconomy Council

1. Frank Rijsberman, Director-General, Global Green Growth Institute
2. Mary Maxon, Associate Laboratory Director for Biosciences, Berkley Lab
3. Shenggen Fan, Director General, International Food Policy Research Institute

Strategic Debate:

› Chairs: Mohamed Ait Kadi, President, Council of Agricultural Development, Morocco & Dirk Pilat, Deputy Director, OECD Directorate for Science, Technology and Innovation
› H. E. Lino Barañao, Minister of Science, Technology and Innovative Production, Argentina
› H. E. Tarsicio Granizo, Minister of Environment, Ecuador
› H. E. Suvit Maesincee, Minister of Science and Technology, Thailand
› Klaus Töpfer, former Executive Director of UNEP & former German Federal Minister
› Thomans Videbæk, Executive Vice President & COO for Research, Innovation & Supply, Novozymes

In his speech, **Frank Rijsberman** stressed that the answer to whether the bioeconomy would actually contribute to strengthening the climate agreement and energy security would not be obvious. Even if many solutions were available in principle, progress to date would be far from adequate to limit climate change to 2 degrees. According to Rijsberman, the traditional bioeconomy, and particularly the current agro-food-system, was a considerable emitter of greenhouse gases. As a consequence, promoting innovations in the modern bioeconomy, such as climate-smart and resilient agricultural practices, carbon sequestration or 2nd and 3rd generation biofuels, would contribute to halting global warming and also solve other major challenges such as food and energy security. In addition, he pointed out that a major driver for future investments in the bioeconomy would most likely be public health concerns, such as poor air quality, rather than rising temperatures.

Mary Maxon addressed the topic of regulatory frameworks of the future bioeconomy. She highlighted the fact that bioeconomy involved bioresources as well as biotechnology. Future bioeconomy products would become increasingly complex (e. g. using a combination of bio-, nano and information technologies) and might constitute entirely new categories. There would be new and unmet difficulties when trying to regulate these. This is why the U.S. government had commissioned the National Academy of Sciences to report on expected future products of biotechnology and their implications for regulation. The expert commission concluded that there would be a need for new and adaptable regulatory systems that consider the many stakeholders and competing interests in the bioeconomy, including new players which might not automatically be “big” companies but possibly also individuals. Furthermore, it would require rigorous, predictable, and transparent risk-

analysis processes that mirror the scope, scale, complexity, and tempo of biotechnology developments.

In his talk, **Shenggen Fan** put the spotlight on the role of trade and investment agreements in the bioeconomy. According to Fan, a sustainable bioeconomy would offer a chance to relieve the anguish of nearly three billion people worldwide who are suffering from hunger and malnutrition, although this would require extensive investments in bioeconomic innovations. In this respect, he particularly stressed the importance of investment in R&D (e. g. through public funds, public-private partnerships, research networks, etc.), infrastructure development and capacity building for all bioeconomy stakeholders. In addition, an open, transparent and fair trade system would be needed in order to achieve inclusive development with the bioeconomy. Fan therefore called for the elimination of distortionary trade policies on bioproducts, support for global interconnectivity in the trading of biomass resources and in global industrial value chains for bioproducts. He also advocated increasing technology transfer, e. g. through South-South cooperation channels.

During the subsequent **strategic debate**, the panelists and the audience discussed which policy steps and regulations needed to be achieved in order to further establish a fair and sustainable bioeconomy. Asked whether a global platform for bioeconomy policy was needed, 92% of the audience voted yes, but were indecisive as to whether the platform should be formal or informal (see figure 2). While in principle the panelists agreed with the audience, **H. E. Lino Barañao** pointed out that the individual needs of each country were shaped by their local economies and resources. In order to avoid future conflict, he called for international and inclusive collaboration so that developing countries could join the bioeconomy market. **H. E. Tarsicio Granizo** also supported this call for more international collaboration, as it was key to fair and international trade. In his opinion, however, whether such a global collaboration platform should be formal or informal required further discussion. In addition to global bioeconomy governance, **H. E. Suvit Maescincee** pointed out the importance of common bioeconomy goals aligned with the SDGs. **Klaus Töpfer** took a step back and pointed to the ethics of a future bioeconomy. While global collaboration, trade and knowledge exchange was important, the protection of intellectual property was similarly critical. According to him, the community needed guidelines for ensuring fair access and benefit sharing, e. g. in the use of genetic resources. Töpfer also referred to the concept of planetary boundaries which was often cited during GBS2018 and according to which humanity should respect ecological limits to prevent

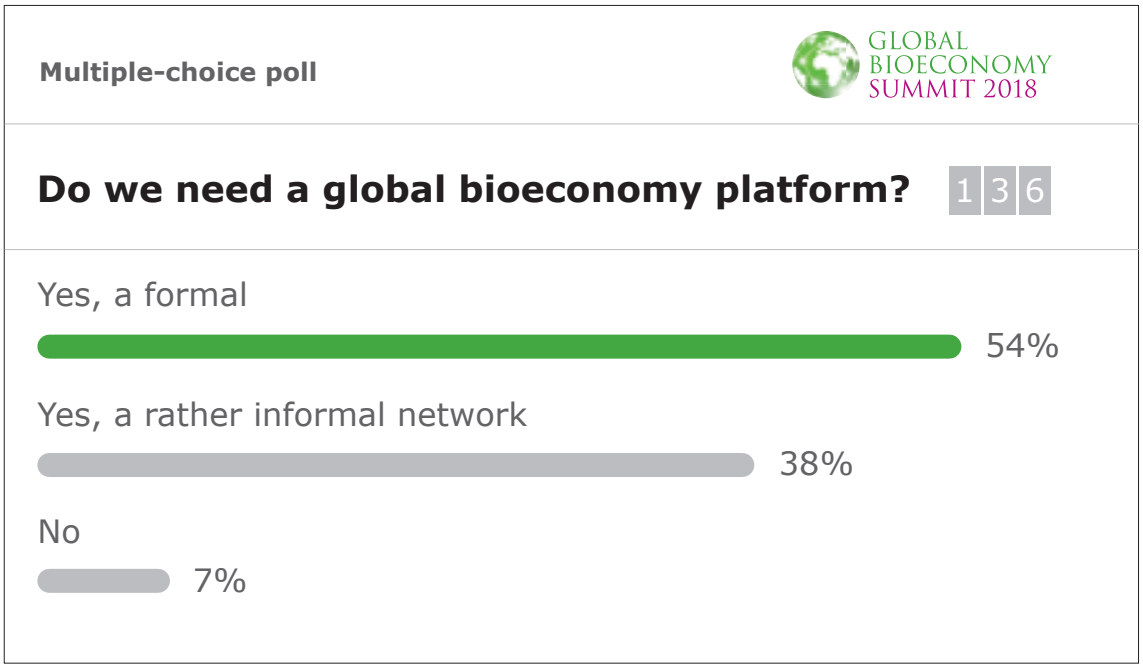
global catastrophic environmental changes. Töpfer asked the audience if this would actually be possible. He raised the question of whether it was not rather a matter of changing planetary boundaries to prevent anything worse happening and, were this to be the case, it would be necessary to discuss the international consequences further.

Finally, with an industry perspective, **Thomas Videbæk** also highlighted the need for international collaboration and common frameworks for knowledge exchange in order to avoid redundant R&D efforts. There was also a need to de-risk investments in the new developments so as to help the industry grow.

When asked how this need for international collaboration and regulations would be realized via political agendas, **H. E. Lino Barañao** suggested an interministerial and interdisciplinary approach, highlighting that this would concern all ministers in charge of bioeconomy-related topics. Once several ministers were on board, they would be able to coordinate their efforts and build a coalition on international policy fora. Building on this approach, **H. E. Tarsicio Granizo** added that the economic potential of bioeconomy would most likely convince even ministers and officials who are not yet familiar with biobased industry. **H. E. Suvit Maescincee** drew attention to bioeconomy innovations and their relevance for emerging or new knowledge-based industries. Rather than being strictly policy driven, H. E. Suvit Maescincee saw public-private partnerships as a potential driver of international collaboration. **Thomas Videbæk** agreed that bioeconomy needed to be made relevant to the private sector as well. Moreover, since topics such as climate change or job creation are on most ministers' lists of topics, if they knew about the potential of bioeconomy to address these issues, it would make it much easier to get the bioeconomy on national policy agendas.

In their closing remarks, the session chairs highlighted the value of global fora such as the GBS2018 for building a mutual understanding of bioeconomy and fostering increased international cooperation.

Figure 2: Slido audience poll



Plenary Session V:

International Collaboration in Bioeconomy Innovation Agendas

Keynote Session:

› Beate El-Chichakli, Head, Secretariat of the German Bioeconomy Council

Strategic Debate:

› Chairs: Waldemar Kütt, Head of Unit Bioeconomy Strategy, DG RTI, European Commission & Elspeth MacRae, General Manager Manufacturing & Bioproducts, SCION

› Yoshihide Esaki, Deputy DG, Ministry of Economy, Trade and Industry & Cabinet Secretariat Japan

› Gertrude Ngabirano, Executive Secretary, East African S&T Commission

› Carl Wolf, Vice President Europe, LanzaTech

In her introductory presentation, **Beate El-Chichakli** summarized the results of the expert survey that was commissioned by the German Bioeconomy Council in preparation for the summit. The main question behind the survey: "What are the innovation and policy agendas that bioeconomy experts are interested in worldwide?" 345 experts across 46 countries answered the questionnaire. When asked what the promising success stories of bioeconomy would be in the next 20 years, biobased energy solutions (incl. biofuels) and novel biobased products clearly led the list of expected successes. In line with the speakers during the summit, the experts pointed out that bioeconomy policy addresses all 17 SDGs. Among these, SDG 12 (sustainable production and consumption), SDG 13 (climate action) and SDG 9 (sustainable innovation, industrialization and infrastructure) scored the highest number of mentions. Experts from developing economies also placed a high emphasis on bioeconomy solutions which reduce poverty and hunger, and increase health and wellbeing.

With a view to policy agendas, the survey asked which policy measures could contribute most to the market success of bioeconomy. Innovation policy was considered as most helpful. About 80% of experts stressed public R&D funding, support for public-private partnerships, and investment in pilot and demonstration facilities, in addition to policy measures incentivizing or ensuring access to private capital for growing biobased companies. The survey also highlighted the promotion of "soft factors", specifically education and capacity building, knowledge sharing between industrialized and developing countries, and consumer information and communication. These were considered important by about 70% of the experts. When asked about research goals and what public funds should best be invested in, the bioeconomy experts appeared to favor high-tech over low-tech investment and technological over social innovation. However, behavioral changes were also considered as valid research goals, e. g. energy saving versus energy generation, reducing food waste versus food pro-

duction, good practices in traditional food production versus new food sources.

The subsequent **strategic debate** built on these results and took them one step further. In order for global bioeconomy innovation agendas to thrive, international collaborations and knowledge sharing are important. But what drives such collaborations? **Carl Wolf** pointed out that governmental policies and regulations could play a major role in facilitating and enforcing international collaboration. According to **Gertrude Ngabirano**, the main driver of collaboration was global trade and the relevant agreements. Importantly, trade relations and collaboration needed to be fair, inclusive, and sustainable for all parties involved. **Yoshihide Esaki** added that global challenges, such as food security and climate change, would drive international collaboration since they are a common theme for all nations and industries.

But how could fair and inclusive collaboration be established? Both **Carl Wolf** and **Yoshihide Esaki** stressed that the international bioeconomy market should grow slowly and carefully, in order not to collapse. In addition, slow but steady growth would provide ample time to establish new business models and regulations for the emerging market. Such regulations for a fair market should be discussed during UN meetings for instance. However, **Gertrude Ngabirano** pointed out that having a discussion forum only at the UN might lead to a closed circle debate among politicians and scientists. Instead, as bioeconomy affects most aspects of life and society, it should be included in climate and trade agreements as well as in high-level global fora, such as the G7. Most importantly, the discussions needed to be inclusive, i. e. include stakeholders across relevant policy fields and economic sectors.

The question of inclusivity was also on the minds of the GBS2018 audience, as two slido questions revealed: “How can society be included in the changing economy?” and “How can collaboration with the civil society and NGOs be ensured?” The experts on stage all agreed that the mindset of society needed to change. Policy could contribute by communicating the benefits that bioeconomy can bring for the economy, environment, and society. As an example of successful collaboration with a variety of stakeholders, **Waldemar Kütt** picked up the example of the European Bioeconomy Stakeholder Panel which involves large and small companies, NGOs, biomass producers, regions, and academia from all over Europe. As a result of a broad and inclusive consultation, in 2017 the panel published a common manifesto which provides jointly developed guiding principles and recommendations for promoting the bioeconomy in Europe.

To close the debate, **Waldemar Kütt** asked a final crucial question: Would the panelists choose to invest in regulations that support and drive the bioeconomy, or would they invest in research and innovation? **Carl Wolf** decided in favor of a regulatory system that promotes sustainable developments. According to him, without such regulations, no new development would make it to the market. In contrast, **Gertrude Ngabirano** was decisive in her vote for investments in research and innovation. She argued that in particular the translation of basic research into the widespread application and commercialization of new developments lacked funding.

Plenary Session VI:

The Way forward – Communiqué of GBS2018

Strategic Debate:

- Chairs: Christine Lang & Joachim von Braun, Co-Chairs, German Bioeconomy Council
- Dirk Carrez, Executive Director, Bio-based Industries Consortium (BIC)
- H. E. Cameron Dick, Minister for State Development, Manufacturing, Infrastructure and Planning, Queensland Government
- Ben Durham, Chief Director Bio-Innovation, National Dept. of Science and Technology, South Africa
- Mauricio Lopes, President, Brazilian Agricultural Research Corporation (Embrapa)
- Gerard J. Ostheimer, Bioenergy Lead for Sustainable Energy for All
- Marcelo Sánchez Sorondo, Bishop & Chancellor, Pontificial Academy of Science
- Aitbate Hatago Stuurmann, Researcher, University of Namibia

The final plenary session of the GBS2018 was both a summary of two densely-packed days, as well as an outlook on the future. The panelists were invited to comment on the GBS2018 Communiqué, which had been distributed to all participants before the session, and to express their thoughts on what the future holds for the bioeconomy.

H. E. Cameron Dick boiled down the essence and the goal of the bioeconomy to one message: "We should not pin the bioeconomy against the economy – economy has to become bioeconomy!" According to him, the bioeconomy would contribute substantially towards fueling, healing and feeding the world in the future. In order to achieve this transition to a biobased economy, **Dirk Carrez** stressed the importance of collaborations between different economic sectors and academia. He pointed out that public-private-partnerships would be an excellent tool for stimulating the symbiosis between different bioeconomy stakeholders. However, he also stressed the need for promoting equal collaborations between northern and southern countries, eastern and western as well as developed and developing countries. **Aitbate Hatago Stuurmann** made an impassioned plea to look beyond the labs and at the big picture instead: "We need to align our (future) strategies, regulations, and policies with the fundamental questions and needs of a global society and the environment. And we need to ask ourselves: Do we really need to consume and thus produce this much?" Stuurman especially called on the younger audience to take charge of their future. With a view to the sustainable and inclusive transformation required, **Marcelo Sanchez Sorondo** underlined the need for all religious leaders to work together in a spirit of shared responsibility to defend our planet's future.

Mauricio Lopes acknowledged that the GBS2018 communiqué would help to guide countries around the world in their future bioeconomy development. By recognizing the need to jointly invest in knowledge and science as an engine of sustainable development, bioeconomy would contribute to dealing with emerging global challenges.

The participants of the summit had made it clear that in their view the bioeconomy needed its own

independent global forum. In this regard, **Gerard Ostheimer** proposed a global bioeconomy association which serves as a knowledge hub for bioeconomy policy and governance, and which links existing multilateral organizations already dealing with bioeconomy issues as well as national governments. Instead of establishing a top-down bureaucratic entity, Ostheimer called for an entity that builds on nationally determined contributions and facilitates equitable international collaboration, ensuring both knowledge transfer and IP rights. **Ben Durham** added that a regularly scheduled bioeconomy summit would further stimulate multilateral collaboration in R&D programs, capacity building, and governance.

Closing the session, **Joachim von Braun** advocated building a grand coalition to design and establish an international mechanism for knowledge exchange and coordination on global bioeconomy. **Christine Lang** summarized the thoughts of the panelists and the outcome of the GBS2018 in one sentence: “International collaboration is the main resource we have – let us use the momentum of this meeting and funnel it into an action plan!”


GLOBAL
BIOECONOMY
SUMMIT 2018
Food Security
Society
Health
Renewables
Energy
Global Bioeconomy Summit
Communiqué

The International Advisory Council of GBS2018

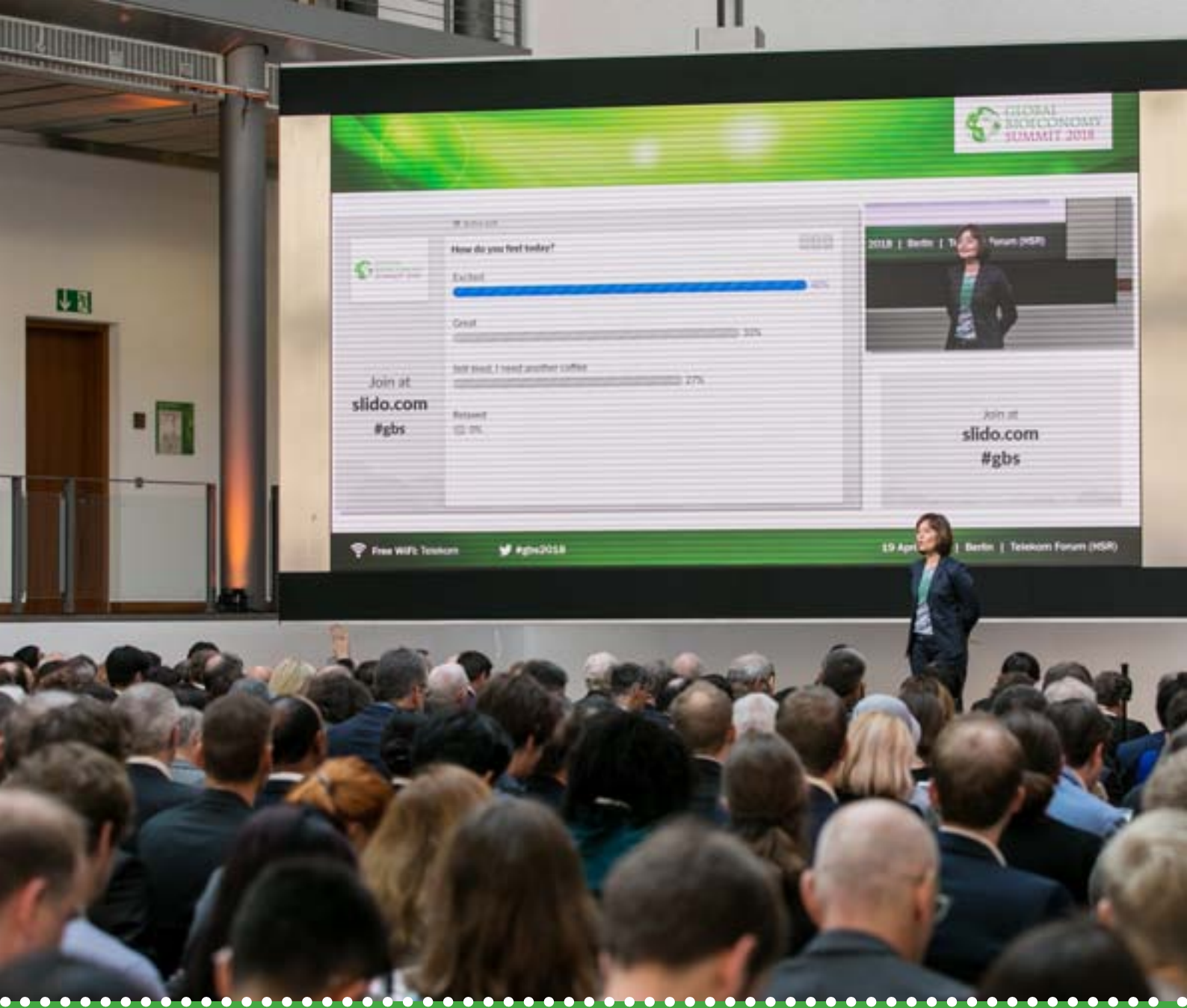
The International Advisory Council (IAC) has been setup as an informal platform of leading bioeconomy experts from both hemispheres to review the state of bioeconomy in different parts of the world and to identify opportunities for an accelerated transition to sustainable bioeconomy. The IAC was first formed for the Global Bioeconomy Summit 2015 and has been maintained, extended and updated for the Global Bioeconomy Summit 2018.

The IAC members have contributed significantly to agenda setting and the workshop program of the Global Bioeconomy Summit 2018. Most importantly, the exchanges within the IAC have resulted in the GBS2018 Communiqué, a set of recommendations for international bioeconomy policy which was presented at the Summit.

Communiqué → http://gbs2018.com/resources/

Country	First Name	Last Name	Biography/Position
Argentina	Eduardo	Trigo	Bioeconomy Advisor to the Government of Argentina
Australia	Ian	O'Hara	Queensland Biofutures Industry Envoy & Professor, Queensland University of Technology
Austria	Josef	Glössl	Initiative Bioeconomy Austria & Vice Rector for Research and International Research Collaboration, University of Natural Resources and Life Sciences (BOKU)
Brazil	Pedro	Machado	Coordinator of Embrapa Labex Europe
Canada	Murray	McLaughlin	Co-chair, Government's Industrial Bioproducts Value Chain Roundtable
China	Yin	Li	Deputy Director-General, Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences
Ethiopia	Neway	Gebre-ab	Former Chief Economic Adviser to Prime Minister
EU	John	Bell	Director Bioeconomy, DG R & I, EU Commission
Finland	Jussi	Manninen	Executive Vice President, Solutions for Natural Resources and Environment, VTT
France	Paul	Colonna	Deputy Scientific Director for Food, Nutrition and Bioeconomy, French National Institute for Agricultural Research (INRA)
Germany	Christine	Lang	Co-Chair, German Bioeconomy Council
Germany	Joachim	von Braun	Co-Chair, German Bioeconomy Council
Germany	Christian	Patermann	International Bioeconomy Expert & former Director Biotechnology DG R & I, European Commission
Great Britain	Achim	Dobermann	Director & Chief Executive, Rothamsted Research
Iceland	Hordur G.	Kristinsson	Chief Science and Innovation Officer, Matís Iceland
India	Renu	Swarup	Managing Director, Biotechnology Industry Research Assistance Council
International Organization	Olivier	Dubois	Leader Energy Program, Climate, Energy and Tenure Division, Food and Agriculture Organization of the United Nations (UNFAO)
International Organization	Rubén	Echeverría	Director General, International Center for Tropical Agriculture (CIAT)
International Organization	James	Philp	Policy Analyst, Science and Technology Policy Division, Organisation for Economic Co-operation and Development (OECD)
International Organization	Frank	Rijsberman	Director General, Global Green Growth Institute (GGGI)
International Organization	Adrían	Rodriguez	Chief, Agricultural Development Unit, United Nations Economic Commission for Latin America and the Caribbean (UNECLAC)
Iran	Omid	Tavakoli	Head of Iran Bioeconomy Committee, University of Tehran
Italy	Fabio	Fava	Professor, Industrial & Environmental Biotechnol., University of Bologna
Japan	Masahiro	Uemura	Director, Bio-industry Division, Ministry of Economy, Trade & Industry

Country	First Name	Last Name	Biography/Position
Malaysia	Zurina	Che Dir	Senior Vice President, Bioeconomy Programme & Delivery Management, Malaysian Bioeconomy Corporation
Morocco	Mohamed	Ait Kadi	President, General Council of Agricultural Development
Namibia	Paulus	Mungeyi	Manager Biotechnology, National Commission on Research, Science and Technology
Netherlands	Jan	van Esch	Senior Policy Officer, Ministry of Economic Affairs & Bioeconomy Strategic Working Group, EU Standing Committee on Agricultural Research
New Zealand	Elspeth	MacRae	General Manager Manufacturing and Bioproducts, SCION
Nigeria	Baba Yusuf	Abubakar	Executive Secretary, Agricultural Research Council of Nigeria
Nordic Union	Geir	Oddson	Senior Advisor, Nordic Council of Ministers
Norway	Mogens	Lund	Director of Division for Food Production and Society, Norwegian Institute of Bioeconomy Research (NIBIO)
Poland	Andrzej	Siemaszko	Director, National Contact Point for EU Research Programs
Russia	Vladimir	Popov	Director, A.N. Bach Institute of Biochemistry, Russian Academy of Sciences
South Africa	Ben	Durham	Chief Director Bio-innovation, National Dept. of Science and Technology
South Korea	Seung Jun	Yoo	Managing Director, Korea Bio-Economy Research Center at Korea Biotechnology Industry Organization (KoreaBIO)
Spain	Manuel	Lainez	Director, National Institute for Agricultural and Food Research and Technology (INIA)
Sweden	Ivar	Virgin	Senior Researcher, Stockholm Environment Institute (SEI)
Thailand	Morakot	Tanticharoen	Senior Advisor to the President, National Science and Technology Development Agency (NSTDA)
USA	Harry	Baumes	former Director, U. S. Department of Agriculture



Interactive Sessions – Q&C from the Audience

In order to provide opportunities for active participation during the plenary sessions the audience had access to an interactive conference tool to vote in polls and to submit questions and comments. These participant inputs were used to enrich the plenary debates and stimulate audience reflections. The results of the polls have been reported directly in the sections covering the plenary debates. On the following pages we list all submitted questions and comments in chronological order. They might serve to complement the plenary reports and to stimulate future dialogues on bioeconomy.

1 | To Yin Li: How much of the growth in Chinas bioeconomy is supply by domestic vs. imported biomass?

2 | To Yin Li: Does China include agriculture (with food & feed) in the bioeconomy, as Europe does? Then the bioeconomy share in China's economy would not be small.

3 | Mittra (2016) poses about the "new bioeconomy of health" which aim to become stronger than ever. Why this matter it is not addressed?

4 | Is there any risk that digitization of bioeconomy threatens biodiversity? It is easier to digitalize resources we use? It is harder to digitalize biodiversity?

5 | Why not the ethics of action for fossil resources?

6 | Bioeconomy does not necessarily mean to use bioresources and to decrease biodiversity. Debate should be focused on how to develop better technologies.

7 | Which are the relevant scales should Bioeconomy be focusing on?

8 | How many of #gbs2018 participants are female?

9 | We keep talking about circular systems. But all systems require input. What are realistic targets in efficiency for example for the future plastics industry?

10 | How does the social implementation of bioeconomy by industry in Japan work?

11 | Why not just prohibiting plastic bags until there is a solution for plastic pollution found?

12 | How can we ensure, that a biobased bioeconomy is not just using even more resources like soil, water etc e. g. biofuel production from corn?

13 | NGOs should be more "inside" players and drivers of bioeconomy developments. Don't only find out about missed opportunities, help to make them happen!

14 | To Mr. Ishizuka: Could you share examples of success stories in the collaboration of the three sectors (government, academia and industry) in Japan?

15 | How many of the people in the audience do actually have a sustainable CO_2 footprint themselves?

16 | Although ethics are universal, personal frames heavily influence specifics/in actment, how do we establish an universally accepted ethics framework?

17 | Everyone is talking about R&D and new technologies to act sustainable. Hardly anyone is talking about changing the economic system. Why?

18 | Yes we need biojet. But also develop technology to make us fly less, like more virtual meeting-rooms with higher quality etc.

19 | Where is the Bioeconomy framework policy for our SEAS, oceans and rivers in all of this?

20 | Environmental challenges are well addressed. Social issues are less in focus but should be part of the core topics to design a transition to sustainable bioeconomy.

21 | Is it really important for everyone to earn more? (Won't the growth in income be less for some than others) How does equality equate to equity among resources?

22 | Is bio-piracy an important issue?

23 | Won't the Amazon blockchain project be too intensive in it's computational investment? (capital for bioeconomy vs. IT)

24 | On the amazon bank of codes, isn't the blockchain tech supporting it extremely carbon intensive? Data Mining for the unique digital fingerprints etc. ...

25 | How do cows benefit from being milked by robots? The dairy industry is one of the biggest CO_2 emitters. Senseless technological fixes won't solve the problem!

26 | Is there any place for public policy in driving bioeconomy innovation?

27 | How to avoid that the Amazonian bank of codes become in a merely extractivist plan to better off a few people and appropriate natural resources?

28 | How to manage impact investment that would help reduce consumption of rich countries?

29 | How much innovation do we really need to drive a bioeconomy? Isn't it primarily a matter of coherent political regulation and using traditional knowledge?

30 | Is there enough biomass for a bioeconomy?

31 | JRC research shows that innovation environments with cooperation of small and large companies work best.

32 | Look at the computer science revolution. Is it small startups or large companies in the driver seat?

33 | How on earth will we manage to cut our demand of animal feed (e. g. soy beans) substantially? Otherwise we won't have enough acreage for sustainable bioeconomy!

34 | Isn't bioeconomy requiring even more resources like soil, water etc. e. g. for biofuel-production? Doesn't the solution has to be to consume less?

35 | Does Bioeconomy need less powerhouses and more SME actors than what we see now?

36 | What will be after bioeconomy?

37 | How important are collaborative business models of SME's in spurring growth and market potentials in the bioeconomy?

38 | List and prioritize top barriers to bioeconomy innovation.

39 | Do GM crops protect the environment?

40 | Apropos payments: How can we ensure permanent high quality scientific work, when the most scientists get bad payments and 2 to 3 years limited contracts?

41 | In your opinion, what role do animal resources play in the bioeconomy and how would you like to see the idea of 'sustainable intensification" operationalized?

42 | Can innovation be a barrier to bioeconomy? How far can we go?

43 | Where does investment in nuclear come into the energy mix?

44 | We are very nationalistic in our bioeconomy developments - when do we recognize that we are global citizens, and we are trying to address a global challenge?

45 | Why are there no women participating in this panel?

46 | When will there likely to be regulatory clarification about whether insects grown on bio-residuals and waste can be used in feed or food production?

47 | The term bwwioeconomy needs to be defined clearly. How will this be done?

48 | Is it all about technology, innovation and substitution bioproducts? What about potentials through a change in consumption, usage of resources, living styles?

49 | The challenge of sustainability is a social challenge. Is it not all about educating people and sharing of knowledge on bioeconomy and technology?

50 | When we observe the EU the negotiations ends when it comes to issues about Agriculture Biofuels Biogenetics. Isn't it there that we have to start?

51 | Climate change mitigation needs to happen now and radically considering the cumulative carbon budget and how little is left.

52 | What could alternative carbon pricing systems look like?

53 | Everyone mentioned the word bioeconomy and trying to define and shape the word "bio", hardly anyone questions the "economy". Shouldn't we rethink our economy?

54 | How important is it really to have a very clear and sharp definition of the bioeconomy? Isn't the bioeconomy (process) a way to give life to the (political) access & benefit sharing Ideas?

55 | What kind of governance can address the mismatch between how developers think their technologies will be used and how they are used in practice?

56 | Bioeconomy now is more expensive than oil based economy. How to make the bioeconomy more fisible?

57 | Do we need public knowledge producers who provide open access to that knowledge to everybody?

58 | Informal or formal international panel on bioeconomy?

59 | Besides technological and regulatory challenges, (how) will world population/households be able to afford sustainable bioeconomy financially?

60 | CPB's environmental intentions are noble, but is misused as a non-tariff barrier. How do we ensure possible international agreements on bioeconomy are not the same?

61 | Shouldn't we start to set targets for the global bioeconomy in the same way as it has been done for climate change under the Paris agreement?

62 | What are the main challenges for international cooperation and how to address them?

63 | How is it possible that figures are being quoted about bioeconomy development and definitions, indicators & contours are not yet clear?

64 | Do we need a global platform to guide national policy, share knowledge and research, or collaboratively avoid negative consequences of bioeconomy development?

65 | Shouldn't we consider the moral ethics of the biobased economy rather than only focusing on mass production, automatisation and GMOs?

66 | The expert leading the bioeconomy will fall on deaf ears if we don't take the public with us. What can we do to better communicate science & gain trust?

67 | Civil society is missing in the collaberation discussion. These are questions for society too.

68 | Aging Japan (and Germany & Co) and growing/young Africa: we may have to learn something from each other...

69 | Benefits, benefits, benefits! Help identify the primary, shared benefits and international collaboration will naturally grow from that.

70 | What about a global Biopreferred type of program to stimulate public acceptance and market uptake of sustainable bio-based products?

71 | How can bioeconomy can take the traditional industrial sectors as machine building with it towards a sustainable economy?

72 | What about the still not answered question on where all the biomass should come from considering food security policy?

73 | Changing diversity of biology from a disadvantage into an advantage is a great idea. How can international cooperation help?

74 | It's hard to define one-size-fits-all bioeconomy models. Isn't better to focus international collaboration to trigger bottom-up approaches rather than top-down?

75 | How can the traditional industry (e.g. pulp and paper) be convinced to be part of the bioeconomy? What policies can support that?

76 | Where should the bioeconomy be placed in relation to the SDGs?

77 | How can we increase acceptance for bioeconomy when we do not learn (and more important confess mistakes) from the past like the first generation of biofuels?

78 | Does bioeconomy really include protection of natural environment as well?

79 | Why is there still no civil society representative in the German bioeconomy council?

80 | Healthier and more sustainable diets means a decreasing meat consumption. Why didn't we mention it directly?

Workshop Reports

The GBS2018 agenda included three parallel workshop sessions with 14 workshops organized in four tracks Bioeconomy of World Regions, Policy, Industry and Innovation & Environment.

In advance to the Summit, 50 high-quality proposals were submitted to a workshop call launched in 2017 and after a thorough review, co-chairs from different organizations were appointed to merge complementary proposals. As a result, all topics were covered in a set of state-of-the-art workshops with expert speakers and different interactive formats. After the event, participants described the discussions during the workshops as lively, intense and highly constructive. Many workshops resulted in new cooperation, partnerships or the initiation of exchange platforms.

The reports on the following pages were written by the rapporteurs and co-chairs of the respective workshops and aim to share messages and outcomes.

Bioeconomy of World Regions
Africa

Authors: Jan Börner, Julius Ecuru, Fabio Fava (Co-Chairs), Gertrude Ngabirano, Ivar Virgin (Rapporteurs)

Abstract

The aim of the GBS workshop Bioeconomy of World Regions: Africa, gathering some 70 participants, was to (i) discuss strategies for bioeconomy development in Africa, including the Mediterranean region, in support of the Sustainable Development Goals (SDGs), (ii) highlight opportunities for international collaboration in the development of African bioeconomies, and (iii) addressing challenges and opportunities for integrating an African emerging bioeconomy into a global bioeconomy.

Through several speed talks, and parallel group discussion, the opportunities and challenges in the development of African bioeconomies were presented and discussed.

The key messages coming out from the workshop were:

- African nations need to develop strategic bioeconomy blueprints to help prioritize investments, government interventions, capacity building and to guide policy agendas for a biobased economic growth;
- Private sector entrepreneurship as well as public sector research and development institutions need to play a leading role for translating scientific innovations in the agrifood, health, and industry sectors into new practices, jobs and a biobased, inclusive economic growth. A conducive policy environment is crucial in this regard, while also developing the necessary capacities to enforce such policies;
- An African bioeconomy agenda should emphasize the linking of African farmers to regional, national and global markets, and seek to catalyze African agro-value chain expansion through foreign investments and multiple south-south-north bioeconomy partnerships and collaborative ventures between African and overseas companies able to facilitate the onsite deployment of bioeconomy technologies and innovations;
- Building national capacity and strengthening regional integration for biosciences related research and development and innovation to promote African bioeconomy including educational programs, capacity building initiatives and research collaborations.

Report

The workshop

The aim of the interactive workshop Bioeconomy of World Regions: Africa was to create an engaging platform to discuss strategies for bioeconomy development in Africa and to highlight opportunities for international collaboration in bioeconomy development. The guiding questions for the workshop included the following:

1. What is the understanding of bioeconomy concepts and what are the strategies in African countries to develop sustainable bioeconomies?
2. What is the unmet bioeconomy potential to achieve the Sustainable Development Goals (SDGs) in the region and how do policy strategies in African countries consider SDGs?
3. What are the challenges in African countries concerning the development of bioeconomies (science policy, potential tension and conflicts, resource competition, jobs, potential winners and losers)?
4. What are the opportunities for collaboration within Africa and internationally?
5. How to achieve a successful integration of an emerging African bioeconomy into global value chains and how to foster cooperation with other world regions in the global bioeconomy?

The presenters and the agenda

The workshop (90 minutes) consisted of four parts:

1. A workshop introduction including presentations of initiatives by Jan Börner, Professor, University Bonn and Julius Ecuru, Icipe.
2. Speed talks, see list below.
3. Group discussion (round table format):
   A. African concepts of bioeconomy, national and macro-regional strategies, and SDG (moderator: Philippe Mengal, Executive Director of the Bio-based Industries Joint Undertaking, BBI JU).
   B. Opportunities and challenges for bioeconomic transformation in Africa (moderator: Ivar Virgin, Stockholm Environment Institute).
   C. Integration of African bioeconomies in the global context and implications for achieving the SDG (moderator: Holger Hoff, Stockholm Environment Institute.)
4. Short presentations of discussion results by the three groups and plenary discussion.

Presenters' institutional affiliations and their topics

- BioInnovate: Presentation of the largest bioeconomy platform in eastern Africa - Julius Ecuru, Icipe.
- STRIVE Project: Interdisciplinary research project consisting of economic, social and natural scientists at the Center for Development Research (ZEF) at the University of Bonn on Sustainable Trade and Innovation Transfer in the Bioeconomy (STRIVE) - Jan Janosch Förster and Jan Börner, Center for Development Research - University of Bonn.
- PRIMA: An integrated research and innovation program on food systems and water resources. Angelo Riccaboni, PRIMA Fundation & The Bioeconomy in the Mediterranean, Fabio Fava, University Bologna.
- Ethiopian Biotechnology Institute: The emerging opportunities and challenges of fostering bioeconomic bevelopment in Africa - Kassahun Tesfaye.
- Applied Biotech Inc. USA/Nigeria: Opportunities and challenges for bioeconomic transformation in Africa: Harnessing Africa's expansive Bioresource for the Bioeconomy - Nwadiuto (Diuto) Esiobu, Florida Atlantic University, CEO Applied Biotech Inc.
- Blue Bioeconomy: Blue growth in the Mediterranean and the Southern Atlantic - Fabio Fava, University Bologna on behalf of Sigi Gruber. EU Commission.

› UNESCO. Opportunity for Bioeconomy in Africa, Need for partnership - Peggy Oti-Boateng, UNESCO Regional Office for Southern Africa.

A Background

A key feature of the bioeconomy is an extending biomass production and processing beyond food, feed and fibre to include a range of value-added products with potential applications in many sectors, such as pharmaceuticals, green chemicals, industrial materials and energy.

Many African countries are endowed with relatively abundant natural resources, including about 60% of the world's arable land, significant potential for solar energy and vast freshwater and marine resources. These resources are, however, unevenly distributed, and agro-ecological niches and biomass production conditions, such as availability of water, land, infrastructure, markets etc., vary widely across the continent. Continued improvements in biomass productivity and an optimization of biomass use, combined with a viable bio-business sector that adds value to primary production, can drive a broader African bio-based economic growth. The African bioprocessing sector is, however, running at a suboptimal level and produces large amounts of waste with severe environmental problems. Transforming the African bioprocessing sector in a way that it adds value to the primary production and converts waste to valuable products in a resource efficient and environmentally friendly manner, will be a central challenge for emerging African bioeconomies.

The development of African bioeconomies is complex and challenging and governments and policy makers in the region face many questions, such as:

› How can countries in sub-Saharan Africa, given their constraints regarding human and industrial capabilities and financial resources, make the most of their large biological resources, using new technologies and new market conditions?
› What type of investments in science and technology platforms, bioscience innovation as well as natural resource management and production systems can best connect small-holder farmers to markets, value chains and agro-processing opportunities?
› How to get there? Which specific investments are needed and how can capacity be built? Which strategies and policies need to be put in place? What type of R&D systems, entrepreneurship, business and financing models need to be fostered?
› How to ensure that investments in the bioeconomy consider social, economic and environmental constraints?

In Africa, only South Africa has a comprehensive bioeconomy strategy currently implemented. Developing regional and national bioeconomy strategies is therefore an important step in the process of moving towards modern bioeconomies in Africa. However, new technologies and changing socio-economic patterns of production and consumption rarely only have positive implications, but can also hold considerable risks. Keeping bioeconomic developments within planetary boundaries is essential in this regard and the global SDG targets are an expression of this ecological imperative. Despite this, early research results of analyzing 43 global bioeconomy strategies in the STRIVE project at the Center for Development Research (ZEF), University of Bonn show a significant gap in governing bioeconomy towards greater sustainability. The large majority of countries with a bioeconomy strategy had neither identified any conflicting goals between SDG achievement and fostering the bioeconomy or had not addressed them with regulatory frameworks. Especially for an African continent with relatively abundant natural resources, but often rather weak governance structures, more efficient regulatory safeguards for socio-ecological sustainability are important, while not stalling aspired economic growth and development.

The messages coming out from the group discussion

In discussions among three working groups, some of the key elements in an African bioeconomy agenda in support of the SDGs were identified. The discussion focused on how to move forward and to what extent countries in the region were able to address the opportunities and challenges of an African bio-based economic growth. The main recommendations from the groups were as follows.

- **African national bioeconomy strategies.** In order to prioritize investments, government interventions, capacity building, and guiding policy agendas for biobased economic growth, there is an urgent need for African countries to develop concrete national bioeconomy visions and strategies.

- **Job creation through biobased economic growth in Africa.** A focus for the bioeconomy in Africa is the creation of new jobs and sustainable, inclusive economic growth. To this end, African countries need to create an enabling environment for private sector led investments and advancements in biobased production. This includes policies and regulatory frameworks creating demand for biobased technologies and knowledge (e. g. certification, quality and environmental standards, public procurement efforts and tax incentives).

- **A broadening of the innovation agenda.** African countries need support to build a capacity in the public research and development sector to link to market actors and translate promising technologies and knowledge into societal benefits at a large scale. This also includes a support for entrepreneurship training and platforms for communication enabling academia to effectively interact with market actors. The European Commission is contributing to this process via tailored policy initiatives and sustaining joint research and innovation projects.

- **Linking African farmers to markets and agro-value chains to benefit from bioeconomy developments.** Diverse and resource-efficient agro-processing, agro-waste and biomass value chains are central in an African bioeconomy and crucial to African farmers and biomass producers, supporting them to diversify their production and connect them to local, regional and international markets. Integrated agro-industrial parks encompassing the whole value chain from farm to processing centers should be promoted as integrated as a holistic approach linking small-holder farmers to value adding opportunities while not underemphasizing the importance of a more local and small-scale everyday bioeconomy.

- **Supporting African biobased companies.** A strong, active and engaged African private sector and in particular small and medium enterprises (SMEs) are crucial for translating the promises of the bioeconomy into functional tools for practitioners on the ground, not last smallholder famers. A challenge is that the private sector in most African countries lacks the capacity and the resources to move research and development efforts to the markets with limited collaboration between knowledge producers and innovators with SMEs. There is thus a need for urgent investments and support to African SMEs enabling them to fulfil their role in deploying modern bioeconomy technologies for African markets. To this end, African countries need to create an enabling environment (policies, incentive structures, intellectual property frameworks, business incubators, venture capital etc.) to facilitate African driven public-private partnerships.

- **Addressing issues of climate change resilience** in the context of enhancing bioeconomy for sustainable development, while addressing Africa's vision 2063 of industrialization, energy efficiency, food security and health.

- **Assess and address tensions and potential conflicts in an emerging African bioeconomy.** Challenges, potential resource conflicts (e. g. food vs non-food biomass production) and socioeconomic challenges (e. g. small-scale vs. large-scale biomass production) in the emerging African bioeconomy need to be addressed. African countries also need to develop capacities to evaluate potential risks and benefits associated with new biosciences, biomass production regimes and value chains. Such assessments should also include the consideration of environmental, socio-economic and social issues (e. g. potential winners and losers).

- **Visualize the potential of bioeconomy technologies in Africa.** Educating and training the African youth in using the bioeconomy and bioentrepreneurship as a tool to support an African SDG 2030 agenda is strategically needed as a long-term solution. An urgent need currently, is to visualize the potential for and benefits of the deployment of bioeconomy technologies in Africa. This could be achieved through partnerships with African and oversea companies commercializing and scaling up existing and functional bioeconomy technologies visualizing societal impact, models and "success stories" of deployment. Such partnerships and support should of course be driven by African needs and livelihood realities and be adjusted to local contexts.

- **Strengthen national and international partnerships and collaboration** and multiple south-south-north partnerships ensuring that African countries access best available knowledge, experience and capital. Such partnerships would draw strongly on Africa's strengths, such as relatively good land availability, favorable climate, large workforce, rapid economic growth. Such partnerships would provide opportunities for sharing knowledge, technology and innovations, revitalizing and modernizing African agriculture and biomass production.

- **Working with global development agencies.** The United Nations agencies such as UNESCO, WHO, FAO, UNIDO and others provide opportunities for leveraging global partnership for knowledge sharing and advocacy in moving the bioeconomy agenda forward in Africa.

What´s next?

The workshop resulted in a number of key messages that will assist various actors in their design of interventions and actions in support of biobased African economies. There was also a common agreement that it is necessary for African countries to develop national bioeconomy strategies. The Global Bioeconomy Summit (GBS) platform, with its resource material and its convening power will be important in this regard. The development of an African regional chapter of the GBS, supporting an African bioeconomy strategy and policy agenda development is also crucial.

The workshop provided a new dialogue platform on collaboration opportunities and potential joint efforts for actors and programs supporting bioeconomy analysis and capacity building in Africa such as the BioInnovate program, the STRIVE program (Center for Development Research, University of Bonn), the PRIMA program and the SEI Bioeconomy program.

While the support to build bioscience based knowledge and technical capacity in the African public R&D sector has been significant, there has been limited support to bioeconomy business development in Africa. Efforts towards incubating and further support European-African private sector partnerships will therefore be of strategic value for the agri- and biobased business sector in Africa and in Europe. Initiatives linking the expanding bio business sector in Europe with partners in Africa and south-south partnership, connecting African public and private actors with their counterpart in countries such as China, Brazil and India will be essential in linking Africa to the global bioeconomy agenda.

Bioeconomy of World Regions
Europe and North America

Authors: David Babson, Waldemar Kütt, Erika Van Neste (Co-Chairs), Enrico Prezio (Rapporteur)

Abstract

The aim of the workshop was to provide an overview of the different approaches and priorities for the development of the bioeconomy, in particular in Europe, the US and Canada, and the need for global cooperation. Speakers from EU, the US and Canada gave an update on the most recent developments of their national and regional strategies. The recently launched International Bioeconomy Forum, co-chaired by Canada and the European Commission, was presented as a new instrument for international cooperation. The subsequent panel discussion focused also on the need and opportunities for global collaboration.

The presentations from the three co-chairs on the bioeconomy strategies in their respective countries demonstrated the diversity of bioeconomy approaches in the different countries. The EU has an overarching bioeconomy strategy since 2012 that goes beyond research and innovation aspects and covers all sectors that produce and use biomass. It is currently updating its strategy, which will also include ecosystems aspects. However, at EU Member States level, Eastern European countries still have to develop national bioeconomy strategies. The US and Canada do not have a broad bioeconomy strategy, but are focusing mainly on research and innovation to develop their biomass potential for greener biobased products and bioenergy and developing the carbon storage potential of biobased solutions. The presentations focused also on the specific challenges that each country is facing in developing the respective strategies.

In the panel discussion, panelists agreed that there was a strong need for more international collaboration on bioeconomy and a forum for more permanent exchange, in particular in view of developing and sharing knowledge and technologies and monitoring the impacts and progress of bioeconomy at global level. This could be achieved through the International Bioeconomy Forum or a more permanent structure emerging from the Global Bioeconomy Summit.

Report

The presentations during the first part of the workshop aimed at answering a number of guiding questions such as what is the status of the bioeconomy in the specific country? Is there a strategy and how it is being developed? What are the main challenges encountered? What are the opportunities for international cooperation in this area?

The European Commission (EC) presented the EU Bioeconomy strategy and its ongoing update. Since the 2012 launch of the strategy, the EC has doubled its investments in research and innovation and established a large public-private partnership on biobased industries. The EC also provided an overview of the national bioeconomy strategies in the Member States and of the benefits that the bioeconomy could bring at economic, social and environmental level. The need to establish an assessment framework to monitor and measure the development and progress of the bioeconomy was underlined.

The second presentation from Barna Kovacs (representing the BIOEAST initiative) focused on how to foster bioeconomy, in particular in Central and Eastern European States, which represents one of the main challenges in Europe.

The presentation of David Babson, representing the US, focused on the technological solutions that have been developed and that could facilitate the transition to a renewable carbon economy (vertical agriculture, engineered ecosystems, carbon storage, carbon capture, etc.).

David Babson stressed the need for society to become carbon negative, stating that even reaching the COP21 targets (aiming only to a reduction of the emissions) would not suffice to slow down climate change.

Erika Van Neste presented the situation in Canada. Canada does not yet have a unified and broad bioeconomy strategy and its governance its spread among several governmental agencies, therefore the challenges are more in the area of coordination and on creating links and synergies among the different sectors. Erika Van Neste also briefly introduced the International Bioeconomy Forum, which Canada co-chairs with the EU and which was set up in November 2017. So far, it includes the European Member States, the US, Argentina, South Africa, India, China, South Korea, Australia and New Zealand and working groups on “microbiome” and on “precision agriculture” have been established. For the panel discussion, the three co-chairs were joined by Vladimir Popov (representing Russia) and Yin Li (representing China). The discussion revolved around two questions:

- What are the issues that need to be addressed at international level for the development of the bioeconomy and could possibly be taken up by the International Bioeconomy Forum?
- What are the areas for international cooperation in the bioeconomy between Europe & North America and other regions (e. g. Russia, China)? What forms should this cooperation take to be beneficial to both regions?

Vladimir Popov explained that the concept of bioeconomy is not widespread among Russian decision-makers and it does not appear in any high-level documents. Instead there are numerous federal programs dealing with the development of biotechnologies. However, the social, economic and environmental challenges at the basis of the development of the bioeconomy have been recognized. Russia is open to international cooperation, in particular in the area of agriculture, food production and processing. The Russian perspective is that international cooperation is needed to develop new technologies (to also share the cost of research) and to tackle mega projects.

Yin Li expressed the need for a permanent international forum for the bioeconomy reuniting scientists, investors and policy makers. Other priorities are raising awareness of the bioeconomy and of its benefits and to change the public perception toward certain technologies. China is open to cooperate, in particular on the development of guidelines to foster the development of the bioeconomy in countries that did not tackle the issue yet. Other areas for international cooperation were mentioned, notably conservation of biodiversity and standardization of data on the bioeconomy.

Erika Van Neste underlined how each country has its own strengths and weaknesses, therefore cooperation can only help to overcome specific challenges and to develop synergies. Cooperation can also be useful to identify best practices across countries.

All panelists agreed on the need for a more permanent global forum or organization on the bioeconomy to discuss and promote a better global understanding of it and monitor its progresses (possibly in a setting similar to the IPCC). This could also be a forum to ensure global policy coherence and discuss possible trade-offs of specific bioeconomy policy developments. In this context, pros and cons of large-scale development of bioenergy with carbon capture and storage (BECCS) were raised. Mr Babson acknowledged that the solution to challenges as climate change and global warming would require actions in many sectors. Technology can contribute a lot to these goals but the sustainability of each technological solution (such as BECCS) should be carefully analyzed.

What´s next?

During the workshop several speakers expressed the need for a permanent international forum. One limit of the Global Bioeconomy Summit is that it takes place only once every two years and in between it is difficult to bring on the discussion with all the stakeholders.

The International Bioeconomy Forum (IBF), launched last year in November and co-chaired by Canada and the EC, includes the European Member States, the US, Argentina, South Africa, India, China, South Korea, Australia and New Zealand, could constitute a possible starting point to develop a more ambitious international mechanism for cooperation on the bioeconomy. Countries that are not participating yet in the IBF can apply to become members at any time and join the debate and the activities of the working groups.

Bioeconomy World Regions
Asia

Authors: Morakot Tanticharoen, Masahiro Uemura (Co-Chairs),
Surachai Sathitkunarat (Rapporteur)

Abstract

The Global Bioeconomy Summit 2015 identified international cooperation in research, development and innovation as essential to advancing the biobased technologies that underpin a sustainable bioeconomy. This workshop discussed strategies for bioeconomy development in Thailand, Malaysia, the People's Republic of China, Japan, Iran and Australia, and highlighted opportunities for collaboration in bioeconomy development among these countries, as well as proposing strategies for integration into the global bioeconomy. Each speaker presented an overview of bioeconomy development strategies in their respective countries, addressing both the opportunities, including the economic potential to address the UN's Social Development Goals (SDGs), as well as identifying the challenges (science policy, resource competition, jobs, potential winners and losers).

The workshop yielded the conclusion that the Asian-Pacific Region needs to place greater emphasis on food for health and livestock feed products and on energy from biomass for alternative energy production to satisfy the Sustainable Development Goals (SDGs), and should strive to communicate the bioeconomy agenda to the policymaking and political levels, so as to promote tangible progress in the upcoming future. Regarding the prospects for regional collaboration, the consensus was that the bioeconomy initiative should also be utilized to assist in the mitigation of negative impacts caused by climate change. In this respect, countries should tighten their joint endeavors and consider to hold regular Asian Bioeconomy Summits to facilitate the exchanges of experience, expertise, and promote further collaborative efforts in driving forward the bioeconomy agenda.

Report

This workshop aimed at providing an international platform for discussion and the exchange of opinions on the bioeconomy development strategies of Asia-Pacific countries, and the establishment of regional cooperation to promote the success of bioeconomies. An open discussion among workshop participants addressed the following three questions:

1) What is the unmet bioeconomical potential to achieve SDGs in the region?

(2) How important is it to increase regional collaboration and how can it be achieved?

(3) Which are the bottlenecks for a more successful integration into global value chains?

From the reports of representatives from Australia, Japan, Thailand, Malaysia, Iran, and the People's Republic of China, it can be summarized that each country is pursuing similar goals in bioeconomy development, and is dedicated to building sustainable economies and societies.

- Australia is currently focused on enhancing value adding to sugarcane products, which is one of the major agricultural outputs of the country, and is working on the re-utilization of agricultural waste as inputs to alternative energy production, such as ethanol and jet fuels.

- Japan is collaborating with ASEAN countries to evaluate the outlook of ASEAN's agricultural input capacities, emphasizing on the oil palm and tapioca industries, in terms of renewable energy use cycles.

- Malaysia possesses a clear set of goals for the development of its bioeconomy. With respect to agriculture, it prioritizes high value-added products, while the development of low-cost and more affordable healthcare products for the people is the primary objective in the medical industry. It also sets goals for the development of bio-industries from renewable resources. In the hopes of achieving these goals, Malaysia has outlined numerous supporting measures to suit the varying needs of these target industries.

- Thailand is focusing on enhancing its bio-industries to add additional value to Thai agricultural inputs, especially sugarcanes and tapioca, such as the biochemical industry. Thailand also aims to promote its bioeconomy by drawing its innate strength of having a diverse national ecosystem, coupled with conservation efforts, to enhance its local economies, for example, through the eco-tourism industry and local product development projects. In addition, it has designated its supporting frameworks and infrastructures, such as the Eastern Economic Corridor of Innovation (EECi).

- Iran has a competitive advantage in biotech businesses, in particular, within medical and agricultural sectors. Iran sets the target for its biopharmaceutical products to secure a 3% share of the global market within 2025, and organizes regular symposiums on bioeconomy.

- The People's Republic of China assigned numerous targets for its bioindustry sector with regards to biomedicine, biomedical engineering, bio-agriculture, biobased manufacturing, bioenergy, biotechnology services, and biobased environmental protection. Its 2020 target aims to achieve a value of 8,000 million RMB for its bioindustry economy sectors and subsectors, with supporting strategies emphasizing on comprehensive sets of factors including finance and investment, policy infrastructures, enhancement of technological capabilities, and international collaboration.

The conclusion could be drawn that a common definition and set of goals should be defined for the bioeconomy initiative. Regional cooperation (via platforms such as regional summits) should be strengthened, and eventually extended to the level of global collaborations, but these will also require the involvement of participants' governments, political processes, and businesses, and not confined only to the academia. In addition, regulations and incentives should be up-to-date, and are to be tailor-made and also harmonized globally for bioeconomy. Niche markets for bioeconomy products and outputs should also be formed, while the disruptive technologies are to be monitored and utilized.

What´s next?

In order to develop and expand the bioeconomy, it is vital to share the value of it among stakeholders. To create an appropriate market for products and services from the bioeconomy, no country can achieve alone, so that international collaboration is needed in terms of holding regular meetings, sharing status and opportunity, harmonizing regulations and including partners in the Asian-Pacific region for creating business value chains for innovation.

Bioeconomy World Regions
Latin America and the Caribbean

Authors: Rubén Echeverría, Adrián Rodríguez, Eduardo Trigo (Co-Chairs), Guy Henry (Rapporteur)

Abstract

The objectives of the workshop were: highlighting progress in policy making for the Bioeconomy in LAC countries; identifying opportunities and barriers for the development of sustainable and inclusive bioeconomies in LAC countries; and proposing collaboration mechanisms based on identified best practices and lessons in policymaking, research for development, and design of incentives and regulation for the bioeconomy. Discussion was organized around three questions: How could the model bioeconomy be useful / opportune to help meeting the Sustainable Development goals?; What are the challenges in Latin American countries concerning the development of bioeconomies?; and What are the opportunities for collaboration among Bioeconomy stakeholder within Latin America and the Caribbean (LAC)?

A Concept Note as background document (http://gbs2018.com/fileadmin/gbs2018/Downloads/GBS18_CN_LACpanel__v13Abr_.pdf) was prepared and distributed in advance to participants; the workshop format promoted interaction among high level officials from LAC Governments, international organizations, the academic and research community, and the private sector. The panelists highlighted the bioeconomy (BE) model as an integrative approach toward meeting the SDGs, stressing the existence of direct links between BE domains and SDG targets, as well as in addressing climate change. Challenges for the development of the BE in LAC were identified in terms of capacity development; creating enabling conditions (e.g. incentives, financing, regulations and market access); information, awareness raising and measurement; governance; and in strategic visioning, prioritization and planning. The need for some form of regional cooperation platform was highlighted, to achieve a critical mass for the bioeconomy.

Report

Guiding questions

(1) How could the model of the bioeconomy be useful/opportune in helping meeting a countries Sustainable Development Goals?

Participants stressed the integrative nature of both, the bioeconomy (BE) model and the Agenda 2030 for Sustainable Development and the coherence among them through direct linkages between different areas of the bioeconomy and targets of several SDGs. Integration was discussed in three senses:

i. The usefulness of the BE model to integrate regional-national and national-global policies, public and private actions, institutional silos and economic sectors, and national territories and landscapes.

Examples provided included:

- the industrialization of agriculture and adding value to biomass at the origin (Argentina, Brazil);
- the promotion of biological-resources-based re-industrialization (Brazil);
- the articulation of private companies, government agencies and society organizations around SDGs (Brazil);
- the articulation of policies aiming at the development of territories and regions, especially in countries with big geographies (Brazil, Argentina);
- providing alternatives to resource limited producers to become part of larger operations and be part of larger value chains (Argentina);
- the articulation of the bioeconomy and SDGs within National Development Plans (Ecuador).

ii. The capacity of the bioeconomy model to integrate SDGs in the social, environmental and economic domains.

For example, in:

- structuring a necessary and robust framework to target SDGs (Uruguay);
- integrating different objectives for biodiversity, food security and agriculture (Costa Rica);

- providing opportunities for integrating SDGs relevant for sustainable intensification in agriculture (Argentina);
- reconciling food production and conservation objectives through sustainable agricultural intensification (Argentina).

iii. The usefulness of the BE model as a framework for climate action, in the context of the Paris Agreement.

For example,

- the integration of biodiversity and traditional knowledge in addressing food security and adaptation to climate change (Costa Rica);
- the integration of initiatives for eco-intensification in agriculture, sustainable energy, competitiveness and climate change action (Uruguay);
- the application of new technologies, such as ICTs, robotics and artificial intelligence in climate change-related initiatives (Argentina, Brazil, Uruguay).

(2) What are the principal challenges in LAC countries concerning the development of bioeconomies?

Several challenges were identified, which can be grouped in five categories:

i. Capacity development:

- Strengthening/developing relevant research and development capacities (Uruguay, Costa Rica, Ecuador);
- developing specialized expertise for Intellectual Property (IP) management and the need for much better science-industry communication and integration (several).

ii. Incentives, financing, regulations and market access:

- Incentives for the private sector, financing and infrastructure (Costa Rica, Ecuador, Uruguay);
- predictability of incentives and market access conditions (Brazil);
- adequate knowledge of regulatory requirements at different levels and development adequate regulations, when required (Brazil, Costa Rica);
- competing with mature fossil based industries (e. g. energy, plastics, agricultural inputs) in the absence of a price on carbon (Brazil).

iii. Information, awareness raising and measurement:

- Information about the potential added value of bioeconomy pathways and products (Uruguay, Costa Rica);
- awareness raising both for stakeholders and the public in general (Argentina, Costa Rica, Ecuador);
- measuring the size of the bioeconomy (e. g. value added, employment, exports) and the impact of BE strategies (Argentina, Ecuador, Uruguay).

iv. Governance:

- Integration of institutions i. e. the different ministries participating in the national BE strategy (Argentina, Ecuador, Uruguay);
- horizontal integration with other relevant sectors, such as logistics, transportations and telecommunications (Argentina);
- articulation of national policies and regional development (Argentina).

v. Strategic visioning, prioritization and planning:

- Balancing eventual trade-offs between sophisticated biodrivers/BE products and low hanging fruit opportunities with great potential and return/impact (e. g. agro-biodiversity);
- the definition of bioregions and identification and quantification of the supply of biomasses (Argentina);
- formulating a national strategy for where to invest, especially in countries with diverse biomasses (Brazil).

(3) What are opportunities for collaboration among bioeconomy stakeholders within the LAC region?

The panelists took note of and agreed with the recommendations for collaboration identified in the Concept Note (http://gbs2018.com/fileadmin/gbs2018/Downloads/GBS18_CN_LACpanel__v13Abr_.pdf) prepared as a background document for the workshop. There was general consensus on the need for strengthening awareness raising and networking throughout the region, stressing three main issues:

i. The use and value/impact generated by the EC funded (bi)regional projects and networks in strengthening EU-LAC S&T cooperation for the bioeconomy.

ii. The existence of regional political fora that could be used to advance regional BE activities (e. g. CELAC, UnaSur, CAN, Caricom, SICA) as well as technical networks (e. g. CyTED network, RedBio, biofuture platform).

iii. The need for a light-kind of regional network for the bioeconomy.

- Discussion about what kind of network is needed. Different functions were proposed, such as: a place where startups can interact together, exchange of relevant information (e.g. on policies), organize visits, showcase and discuss case studies, and online courses (e.g. such as the one organized in Argentina by MINCYT and The Cereal Exchange of Buenos Aires);

- it was stressed that it is of importance for the regional network is to achieve a minimum critical mass for the bioeconomy.

Other issues raised in the discussion:

In the general discussion other issues were raised:

- The relevance of the BE model for countries now dependent on petrol resources when their reserves will get depleted. The Minister of Ecuador indicated that the BE model is an answer of his country to such worry. When oil has depleted there is the bioeconomy!
- A global strategic challenge that needs to be seriously addressed as a base for future discussion on the bioeconomy is how to internalize the true value of oil-derived externalities (environmental costs). This should have a huge impact on relative prices of biobased vs petroleum-based products.
- The need to incorporate other issues in regional LAC BE discussions was also mentioned; for example: water management/lack of water/price of water (ecosystem services); circular economy, carbon storage; and family agriculture.
- The BE as part of a social responsibility model; BE can help to solve challenges now faced by countries.

Principal outcomes/messages

From the workshop the following main messages were identified:

- The value of integration provided by the bioeconomy model is seen as very positive by the countries;
- the challenges being faced by many of IP, industry-science relation, regulations, markets, need for incentives and other enabling conditions;
- the existence of low hanging fruit opportunities, especially in agro-biodiversity and the use of residual biomass;
- the need for continued and strengthened awareness raising activities in the region;
- the need for a regional BE network to achieve a minimum critical mass, linked to regional agencies (e. g. CEPAL, IICA, FAO, other).

What´s next?

In response to the requests for the development of a regional BE observatory/network, made both at the Regional Seminar LAC Bioeconomy 2018 (ECLAC, 24–25 January 2018) and at this seminar, with the support of the German cooperation, ECLAC is taking the lead in the organization of a workshop to assess the state of development of policies for the bioeconomy in six countries of the region (Argentina, Brazil, Colombia, Costa Rica, Ecuador and Uruguay) and from there will identify areas of cooperation, discussion and exchange for the development of a Latin American Bioeconomy Policy Network. The expected outcome of the workshop was launching the network with the commitment of at least four countries. In parallel, the Inter-American Institute for Agricultural Cooperation – IICA, with a presence throughout the region, has been showing a concrete interest in the bioeconomy model and its potential as a framework to help address challenges of poverty, rural employment, agri-chain competitiveness and environmental impact. The agency is currently formulating an action agenda for the organization of a regional network on the bioeconomy. In addition, the International Center for Tropical Agriculture – CIAT, is advancing its regional biosciences platform to strengthen national program research capacities. It is drawing up a strategy whereby its focus on sustainable food systems will be in line with the bioeconomy principles.

Industry
What works and why – Successful Implementations of Industrial Bioeconomy

Authors: Matthias Braun, Yoshiyuki Fujishima (Co-Chairs), Ricardo Gent (Rapporteur)

Abstract

This workshop aimed at highlighting examples of biobased manufacturing which may serve as models for different industry sectors and encourage a shift from fossil based to biobased manufacturing. Three main questions should be answered: What worked and why did it work? What obstacles needed to be overcome? Which framework conditions have to be in place to encourage biobased manufacturing?

There were examples given of innovative new bio-based materials on the market and a discussion on how to encourage an industrial shift to biobased manufacturing by R&D, easy access pilot facilities, increase of public awareness for biobased products and possible industrial policies for their introduction.

The workshop agenda included a panel of experts and impulse presentations to share ideas and views about common issues to motivate a shift from fossil to biobased manufacturing.

Report

The session was opened by welcome talks of the co-chairs and with grateful words to the many people who decided to join the workshop.

Five presentations were given by representatives of Sanofi Aventis, BASF, AB Enzymes, Mitsubishi Chemicals and Kaneka.

Matthias Braun, Vice President of Sanofi Aventis, gave an overview of bioeconomy activities in the German bio-industry and talked about Sanofi's artemisinine production and the future of emerging biotechnologies such as genome editing. He covered conditions of the present and the future of white, red and green biotechnology.

Karl-Heinz Maurer of AB Enzymes, member of the German Association of Biotechnology Industries, talked about strategic innovation alliances to foster innovation and how to catalyze such alliances, funding, communication as well as education and training, and why these aspects are important. Carsten Sieden, Senior Vice President of BASF, talked about the shift of the chemical industry

from fossil to biobased production and the cost issues related to such a shift. He also covered the questions of what is possible and what are the dilemma. He showed a video of the BASF approach for replacement to biobased products.

Prior to the two Japanese company representatives, Yoshiyuki Fujishima, workshop co-chair, briefly introduced the history of the Japanese bioeconomy and related R&D programs as well as the main topics of recent company activities.

Yoshihiro Fujimori of Mitsubishi Chemicals' Advanced Polymer Division talked about biobased and biodegradable plastics development and commercialization. His examples included plant based polyester bio-PBS, poly carbonate Bio-BENEBiOL and Engineering plastics DURABIO and their industrial applications. Erwin Lepoudre, Kaneka Belgium NV Business Manager, talked on marketing and issues of plastics. Kaneka has utilized its polymerization as well as fermentation technology to introduce marine degradable bioplastics PHBH to cope with micro plastics issues. He elaborated on benefits of such materials and their waste management.

Instead of a panel discussion, all available time was spent by the experts to answer the following questions from the audience:

› **Is a mixing of biobased and fossil based feasible?**
"Yes" (by BASF and Mitsubishi)

› **Bio does not automatically equate to sustainable, could you comment on this?**
"Fossil-based routes vs. biobased routes: There is a need to consider economic, ecological as well as social parameters."

› **How do large companies deal with risks?**
"Kaneka has a wide expertise to cope with needs. Mitsubishi gained a unique property not achievable by fossil-based approaches." BASF: "Both big and small companies push the boundary forward. Partnering is important for big companies, too. Budget division to various technologies is defined."

- **Do the represented companies have a policy to collaborate with tropical countries?**
  "The Nagoya protocol is an international agreement and companies are careful to abide by it. Rare raw resources will not be used from nature. Joint development should include bilateral agreements."

- **How to choose the most suitable feedstock?**
  "IP issues of high risk must be solved. From the talk of BRAIN we learned, that CRISPR/Cas can enable fast processes but at the same time, one needs to have slow, conventional processes as well. Biodegradable material can be made from waste oils but one needs to be sure about the market needs."

- **Can you make use of marine biomass?**
  "If 20 to 30 tons of material can be supplied at once, then yes."

- **Is there a typical marketing mechanism or approach for biobased plastics?**
  "Biobased polymer supply is most limiting. It is not easy. Innovating new bioplastic takes time. One needs to compete with cheap commodity plastics. Finding the right market niche takes time, bioplastics are no exception here."

- **Should we focus on sustainable rather than on biobased business?**
  "The first important step is to create a market. Some bioplastics come from fermentation of sugar or fat. Improvement is incremental."

- **What do you expect from governments?**
  "There must be several losers. One important element is availability of biomass. Drop-in research should be encouraged."

- **If you use biomass as raw material, how much product is generated? And how much of waste?**
  "There is a lot of variation in process efficiency."

- **Can innovation come from governments? Can you address R&D demands to governments?**
  "The garage did not create Steve Job's innovation. It were the people in the garage who created innovation. Innovation needs to have people to create, bosses to back it up, marketers to sell it. In the case of industrial enzymes, principles may be found by university but innovation is made by industry. Upscaling is also an important issue."

What´s next?

The session went well with a lot of interest and input from international organizations, governments, universities as well as industries. In the future, such industry sessions should have more segmented topics such as:

- Policy to support industry
- International collaboration of companies
- Sharing of small/midsize company success stories
- Manufacturing industry and primary industry collaboration

Industry
Bioeconomy Financing – Bringing Innovation to Market

Authors: Harry Baumes, Anne-Hélène Mathey (Co-Chairs), Chanchoura Schmoll (Rapporteur)

Abstract

The bioeconomy presents a tremendous opportunity to mitigate the impacts of climate change and transition to low carbon economy, while promoting economic growth, prosperity and societal well-being. Although the benefits are positive and promising, the bioeconomy is in the early stages of development and governments around the world are still developing policies to support the bioeconomy and assessing what their role is in helping companies overcome the "valley of death". A lack of financing for bioeconomy projects has been identified as barrier to the deployment and commercialization of bioeconomy technologies and supply chains.

The workshop included a panel of expert speakers from both the public and private financing world and two bioeconomy companies. It focused on the public and private financing/investment of innovative bioeconomy technologies. The objectives of the session were:

- To highlight the opportunities and challenges in moving companies from S&T to commercialization;
- identify alternative approaches to de-risking steps along the supply chain;
- share success stories and lessons learned; and
- identify key success factors.

The workshop generated discussions around bioeconomy project financing and provided real world insights from two leading bioeconomy companies.

Three key themes emerged from the workshop:

1. Private and public funds are often needed to fund a bioeconomy project, with public funding as collateral financing to help de-risk the investment.
2. There is a need for value co-creation with investors (e.g. Born Global and Celluforce- Schlumberger).
3. There is a shift towards projects that can generate multiple values (e.g. bioenergy or biorefinery parks with multiple partners in closed loop system).

Report

The Bioeconomy Financing – Bringing Innovations to Market Workshop was held on Thursday, April 19, 16:45 - 18:45. The session included a panel of three expert speakers from both the public and private financing world and two bioeconomy companies. Harry Baumes opened the workshop by welcoming the audience and introducing Anne-Hélène Mathey, who moderated the panel.

The guiding questions for the workshop were:

- What are the prerequisites for successful financing on the investor and financial market sides?
- What kind of investor is the ideal investor (bank, business angel, crowd funding, venture funds, corporate investors)?
- Can, public policy stimulate investment in new technologies? If so, how?

What are the prerequisites for successful financing on the investor and financial market sides?

Kimberly Samaha, who is the Chief Executive Officer of Synthesis Venture Fund Partners and Born Global, provided her perspective from the private financing world. Her company manages a portfolio of undervalued energy assets that are currently being transformed into closed-circle, zero-waste energy parks and biorefineries. In her remarks, Dr. Samaha emphasized the changing nature of bioenergy projects and the need for projects with multiple values or revenue streams. She indicated that her investors were interested in "value co-creation". For example, a Born Global project in Maine will include a bioenergy facility as its anchor and will be co-located with a shrimp farm, a greenhouse operation, carbon capture and storage capability, intensive aquaculture and eco-tourism. This model creates immediate and increasing revenue as new technologies are integrated to monetize waste streams.

Dr. Samaha also indicated the multiple goals of the Born Global's energy project made it possible for her to leverage both public and private funding. Along with private investor funds, the company received a grant from the Government of Maine to develop the project and help the state meet its rural economic development goals.

Dr. Martin Langer, Executive Vice President Corporate Development at BRAIN spoke about his company's experience with private financing and the key success factors for the company. BRAIN is one of Europe's leading technology companies in the field of industrial or "white" biotechnology. Dr. Langer spoke about the "4P's" of building a growth orientated business:

1. Products – look for a growth market and provide unique solutions and disruptive products;
2. patents – build up strong intellectual property;
3. people – have a good team of technicians and management; and
4. performance – build reliability by learning from previous successes and be realistic about timelines by under promising and over delivering.

By following these principles, the company grew from a small biotechnology company providing client solutions to become one of the first publically traded bioeconomy companies on the Frankfurt Stock Exchange. Over the years, BRAIN built a solid reputation of excellence, as well as a proprietary BioArchive that allowed them to access private loans, venture capital, and eventually, equity financing through an initial public offering on the Frankfurt Stock Exchange.

What kind of investor is the ideal investor (bank, business angel, crowd funding, venture funds, corporate investors)?

Both Celluforce and BRAIN worked with a variety of investors, and both companies indicated that the ideal type of investor was one who was strategic and patient. For both companies, different financing options were used at different stages of growth.

Sébastien Corbeil, the CEO and President of Celluforce, spoke about his company's experience accessing public and private funding. Celluforce is a world leader in cellulose nanomaterials and produces CelluForce NCCTM a form of Cellulose NanoCrystals (CNC). A large proportion of the academic research for CNC was publically funded through research grants at McGill University (Montreal, Quebec, Canada), and later technology development was undertaken by FPInnovations, a public-private forest research and development institution in Canada. During the demonstration and pilot plant phase, industrial partner Domtar joined FPInnovations in the initiative and created the company.

It was during this phase that Celluforce ran into some significant challenges. It produced at full capacity without considering customer applications and market development. In addition, CNC was a new material that required regulatory clearance in Canada and the United States. The company had to invest heavily to develop product standards, and needed more research on market development. Ultimately, the company ran into the "valley of death", but crossed it by seeking out new investors, Schlumberger and Fibria and accessing a grant through Sustainable Development Technology Canada (SDTC), an independent agency funded by the Government of Canada to support clean technology projects and companies. Schlumberger became Celluforce's main off-taker and worked with the company to develop applications for CNC in their oil and gas operations.

Can public policy stimulate investment in new technologies? If so, how?

Public policy has been a significant driver in new technology investments in Canada's forest industry. Jean-François Levasseur, the Director of Industry, Innovation and Indigenous Programs Division of the Canadian Forest Service, Natural Resources Canada shared his perspective. In Canada, the forest bioeconomy has been identified as an important part of Canada's transition to a low carbon economy. A Pan-Canadian Forest Bioeconomy Framework was adopted in September 2017, and sets a vision for Canada to be a global leader in the use of sustainable forest biomass for advanced bioproducts and innovative solutions.

There is a fully integrated and well-coordinated suite of dedicated programs offering grants and other funding to facilitate industry transformation and relevant bioeconomy technology development all along the innovation spectrum in Canada. The continued presence of “sector targeted” public funding at all the stages is a factor of success and enhances overall coordination.

Public-private funding mechanisms have been extremely important in de-risking new technologies and leveraging private funding. Philippe Mengal, the Executive Director of the Bio-based Industries Joint Undertaking (BBI JU), spoke about his experience with the €3.7 billion public-private partnership between the EU and the Bio-based Industries Consortium (BIC). The EU contributed €975 million to the fund, while €2.7 billion was provided in private sector contributions. The BBI Joint Undertaking funds research and innovation projects from technology development to full-scale deployment. The initiative has already funded 6 flagship biorefineries and 20 demonstration plants.

Public policies that support the transition to a low carbon economy or the use of renewable resources for energy, food and materials create new market opportunities for companies. The stability of these policies or “policy certainty” emerged as key topic of discussion during the question and answer portion of the workshop. The majority of our panelists and the audience felt that policy certainty in the bioeconomy increased investor confidence and helped de-risk investments.

What´s next?

The workshop generated some excellent discussions around bioeconomy project financing and provided real world insights from two leading bioeconomy companies. Three key themes emerged from the workshop:

1. Private and public funds are often needed to fund a bioeconomy project, with public funding as collateral financing to help de-risk the investment.
2. There is a need for value co-creation with investors (e. g. Born Global and Celluforce-Schlumberger).
3. There is a shift towards projects that can generate multiple values (e. g. bioenergy or biorefinery parks with multiple partners in closed loop system)

There were no concrete future collaborations, initiatives, networks or platforms that emerged from the workshop. Rather, the workshop provided insights into the increasingly varied financing mechanisms that bioeconomy projects can access by being cross-sectoral in nature. While this does increase complexity, it is also multiplying opportunities. The successful companies who presented at the workshop showed that being capable of harnessing those opportunities were key to their growth.

Industry
Bioenergy and Biorefineries: Innovations and Futures

Authors: Steve Csonka, Ulrich Schurr (Co-Chairs), Ulrich Schurr, Moritz Leschinsky (Rapporteurs)

Abstract

Biorefineries are promising sustainabe and efficient conversion of biomass to products. To deliver to this high demand and expectations, they have to be developed by optimizing and integrating feedstock provision, conversion technology, product portfolio as well as sustainability, competitiveness and market perspective. The workshop therefore covered feedstock options ranging from lignocellulosic biomass and algae to biomass waste streams as well as photoautotrophic production and production for CO_2. A diversity of conversion technologies, their limitations and opportunities were discussed. The aim of the workshop was to kickoff intensive interactions between key stakeholders from research, industry, investors and regulators to identify opportunities and current limitations as well as ways forward to realize biorefinery capacities globally at industrial scale. Application options in high value chemicals, bulk chemicals and energy (specifically aviation fuels as a special case) were discussed.

Report

The workshop started with a short introduction into the aims and targets of the workshop by Uli Schurr introducing the main three topics that the experts should discuss during the workshop:

- Key challenges and opportunities in feedstocks and processing technologies.
- Ways forward towards integrated biorefineries at industrial scale.
- Key regulation and (market) obstacles.

These topics address major themes of state-of-the-art biorefinery research and implementation and were used in the world café-style interactive part of the workshop by the discussion groups as guiding questions.

In an in-depth talk, Andreas Schmid (Helmholtz Center for Environment Research) introduced the concept and opportunities of (photo)autotrophic biocatalysts in the context of biorefineries. He specifically highlighted the limited land resources and proposed hydrogen from biological sources or artificial photosynthesis as an alternative and efficient way. In his talk he presented ongoing research to

link photovoltaics with CO_2 and H_2O electrolysis and coupling of these to Clostridium fermentation to platform chemicals such as butanol and hexanol. Biotechnology could also utilize CO_2 directly by pathway design. While this is still in the laboratory state, the expectations that these technologies become available soon are high.

Lauri Hetemäki (European Forestry Institute) described in this talk the opportunity of wood as feedstock for biorefineries. The diversity of regions and feedstock is definitely a challenge for lignocellulosic biorefineries, but significant advancements have been achieved in recent years.

Jörn Viell (AVT RWTH Aachen) highlighted differences between traditional fossil-resource based refineries and biorefineries. He first demonstrated the importance of the low concentration of carbon in feedstocks and the relevance to handle the large amounts of water in biomass-based refineries. He therefore raised novel separation technologies, integration in existing value chains and wastewater treatment as key questions for biorefineries. In today's industrial processes energy efficiency is one of the main drivers of integration. However, due to the lower temperature and energy regime in biorefineries, other efficiency gains need to be used for integration. A third significant difference between refineries and biorefineries is the cost structure. While it is dominated by raw materials in fossil-resource based systems, feedstock in biorefineries is (today) only 50% of the cost, while auxiliaries play a very important role. He concluded by the statement that success in biorefineries will be driven by efficiency of mass, energy and cost.

The role of fragmentation of biomass for biorefinery processes was the focus of the presentation by

Moritz Leschinsky (Fraunhofer CBP). He informed the audience that the focus of their activities is the scale-up beyond the pilot scale and deduced the CBP-approach towards a organosolv-based fractionation process and the generation of value from many of the biomass fractions obtained. The biorefinery pilot plant is an example of the need of such large-scale demonstrators to generate knowledge on processes, process integration and improvement as swell as scale-up and engineering of biorefineries. He regarded parallel valorization and market implementation, investment costs and the difficulty to finance respective demo plants as main challenges.

Paul Colonna (UNRA, France) developed an in-depth analysis of the differences in cost structures at the level of products in fossil-based refineries and biorefineries. He also highlighted the link of energy prices (especially natural gas) for the implementation of refineries. He exemplarily worked out the case for methionine as a very interesting higher value product from biorefineries.

In the final presentation, Steve Csonka gave the perspective of aviation industry with a special focus on sustainable alternative jet fuels (SAJF). He explained significant progress in technologies and implementation but illustrated significant challenges with respect to commercial viability. So far, production prices are not competitive with petro-based fuels due to the low price of petroleum, the necessity to generate a new industry accompanied with the aversion to risk and low reward in available capital. Adaption of policies could be a game changer when global regulation would be consistent, long-term and oriented to a level-playing field with fossil-based systems. Cost reduction and investment into R&D are urgently needed. Feedstock scenarios would be well positioned to generate and demonstrate the additional value of bio-based refineries by delivering improved ecological benefit as well as new income opportunities. He expressed the expectation that viability of biorefineries will depend on additional revenues and services provided as well as the integration into other facilities and industries.
Following the impulses of the speakers, an intensive discussion in working groups followed and addressed main topics on the future of biorefineries, such as:

- Challenging and gaps in upscaling integrated biorefineries.
- Best strategies to develop vibrant biorefinery industry and commercialization of the concepts.
- Policy support to develop and implement sustainable biorefineries.
- Demands in research and development.
- Market opportunities and likely products.

The discussion of the 50+ participants was intensive and led to the main conclusion that:

- there will be a multitude of biorefinery concepts and implementation. These range from small scale to large scale dependent on feedstock, technologies and products. There will be a diversity of regional solutions as well as implementations that aim at global markets. These will have different opportunities, but all have the chance to generate valuable business cases – dependent on integration opportunities and market orientation, but opportunities will strongly depend on policies. The path to implementation will also build on the cooperation of SME with global players. Major differences with respect to the setup of biorefineries with respect to technology, but also the relevant business cases will be between premium products and bulk commodities.
- Given the diversity of products from biorefineries, there is the need for different business cases and therefore R&D strategies that need to be implemented. Towards a future implementation path, it will be necessary to add – in addition to still urgently necessary discovery-oriented R&D activities – responsiveness of research and innovation to demands of implementation pathways.
- Policy frameworks are essential to make the diverse solutions feasible and translate them into practical facilities and applications. It will be key to develop and implement policies to provide level-playing field between fossil-based refineries and biobased refineries. These policies need to include system-wide benefits like environmental services of feedstock production and waste utilization as well as the benefits from products – like, for example, biodegradability, life-cycle improvements as well as climate change impact. To establish suitable investment landscapes, reliable, fair and long-term oriented policies need to be established. Consistency of policies at the regional and global market are especially important for globally traded products. Reliability of policies at least during the period of investment are needed.

What´s next?

A range of facilities are already on the way towards commercially valuable products. Few installations are running, some more are upcoming. The workshop helped to establish stronger interactions between the participants of the discussion on alternative pathways towards integrated biorefineries. It will be important to continue the discussions beyond the workshop and build network of biorefineries in implementation and R&D. First discussions have been started on closer interaction of regions and countries in the context to establish suitable solutions based on local and regional availability of feedstock, technological opportunities and products ranging from premium to bulk.

Industry
The Great Convergence: Digitalization, Biologicalization and the Future of Manufacturing

Authors: Gerry Byrne, Rafi Wertheim (Co-Chairs), Markus Wolperdinger (Rapporteur)

Abstract

The workshop discussions and findings clearly confirmed the hypothesis that the process of convergence between the technological world and the biological realm is already underway and is likely to cause a major paradigm shift in the future. While the conceptual definition of "biological transformation" was not discussed in detail, the participants recognized the need, as well as the opportunity associated, to expand the concept of "Bioeconomy" – as it has been perceived so far – to encompass all relevant principles and processes also outside and beyond biotechnological concepts. Major topics discussed during the workshop were: the global dimensions of the development and its relevance for both industrialized and developing countries alike; the need to manage the change process by establishing an inclusive, agile governance framework; the implications of a democratization of technology; the necessity to involve both civil society and the social sciences early on in the process of biological transformation in order to analyze its capacity to address societal problems as well as its potential social implications; and an outlook towards how the process could trigger disruptive innovations in traditional industries.

Report

Rafi Wertheim introduced the concept of biological transformation defined as the process of increasing the utilization of biological resources and applying the principles in technology.

Gerry Byrne, Markus Wolperdinger and Robert Miehe presented the latest findings of two recent studies on biological transformation:

(1) the white paper »Biologicalization: Biological Transformation in Manufacturing« published by the International Academy for Production Engineering (College International pour la Recherche en Productique, CIRP) introduces the principle of biological transformation in engineering, while

(2) the Fraunhofer pilot survey on biological transformation »BioTrain« analyses possible scenarios, fields of action, potentials, and demands of

a biological transformation of the manufacturing industry.

The BIOTRAIN study illustrates biological transformation in manufacturing by giving various examples, for instance bio-intelligent manufacturing cells (bioreactors producing material for additive manufacturing). The preliminary findings suggest that essential fields of action are, amongst others, the development of “biotech interfaces”, new materials and fabrication schemes, social dialogue, and knowledge transfer between the different scientific disciplines.

Claus Fuglsang (Novozymes) addressed the history of biological transformation of industrial manufacturing by highlighting examples from the 20th century, such as using enzymes to increase the efficiency of detergents, as well as to prolong the shelf life of baked goods. He emphasized that merging of biotechnology with digitization may lead to cost reductions thanks to the ability of sorting and analyzing big data, and thus enables a “democratization of biotechnology”.

Conrad von Kameke (Bioinnovators Europe) posed the question of how we can build trust in the governance of the emerging process of biological transformation, and introduced recommendations to attain this goal: given that technology development is oftentimes ahead of policy formulation, the government cannot be expected to handle the responsibility alone; hence, assuming ownership of arising issues is crucial. Learning from debates on biological systems and products in the past, it becomes obvious that trust in such products by the public is not attained automatically through regulations or labelling. Instead, we should involve those who understand human thinking and the social process of trust building, such as cognitive scientists and ethicists and set up an interdisciplinary dialogue.

Discussion:

What are the participants’ thoughts on the new concept and terminology?

The workshop participants were invited to comment on the hypothesis that the convergence process »from nature to innovation« will lead to new, sustainable products and processes and thereby initiate a paradigm shift.

Several participants expressed the opinion that the question is not if the development will happen, but rather how fast it is going to happen. It was emphasized that digitalization and biology are already converging, and AI/machine learning is going to accelerate this process even further.

While the term “biological transformation”/”biologicalization” was not explicitly commented on, the opinion was expressed that the existing concept of “Bioeconomy” may well be expanded by applying it not only to biological resources but also to a wide range of – essentially all - processes, thereby reinventing the “Bioeconomy” concept.

It became clear that the convergence is already noticeable, but that there are different languages used and thought processes applied, still.

The following questions emerged from the lively discussion among the workshop participants and the expert panel:

What are regional dimensions and opportunities of biological transformation?

A participant from the United States described biological transformation as a critical pillar for the next generation economy, and pointed to the great importance of the topic in the US American context: a range of American universities are currently working in this field, a number of US studies on the topic of »biology as technology« have been published, and a large amount of financial resources have been dedicated to it. An important goal in this context is to understand the complexity of biology to enable better production.

A participant from an environmental research institute pointed to the gap between the global south and global north, and asked if less developed countries will be able to follow this new, very complex convergence. The panelists believed that, similar to the development related to the dissemination of smart phones, e. g., in Asia, biological transformation could present a great opportunity for development associated with a better access to relevant products by the world population through decentralization, and facilitate the creation of new types of distributed manufacturing required to bring products to people.

How can we manage the change process?

A number of participants shared the opinion that regulatory standards are an important challenge

because of the speed with which the convergence is taking place, while regulatory changes typically need time.

The question was raised what kind of regulatory framework would work in this context. The panelist Conrad von Kameke argued that agile governance is required, which has to be integrated with traditional governance. There is an increased responsibility for self-regulation and for earning the trust of civil society. The UN Sustainable Development Goals and Human Rights Declaration are also goalposts of technology governance.

On the other hand, the panelist Claus Fuglsang argued that it is important to demonstrate the safety and benefits of the emerging technologies rather than to foster regulation.

Furthermore, an entrepreneur in the audience pointed out that the application of the precautionary principle can also hinder disruptive innovations (for instance, it is currently illegal to feed insects to chicken).

Does biological transformation promote the democratization of technology?

Referring to the panelists' statements that biological transformation will enable a "democratization of biotechnology" and that "agile governance is required" to manage the change process, a workshop participant critically questioned whether such a development would really be beneficial: It is critical to define who the decision-makers within the governance systems are. In particular, it was viewed as problematic if this would imply that industry takes

on the role of writing regulation itself. In response, Conrad von Kameke pointed out that it should not be left to industry alone to fill the gap between the technology development and the policy-making, but that there is a common responsibility to find out how the change process can be governed in the meantime.

Another sub-question referred to the democratization of such technologies and scrutinized if this might imply that "everyone can mess around with DNA". Claus Fuglsang affirmed that there is a trend towards open source technologies in this realm, i. e., making the technology free of charge, and pointed to the example of CRISPR/Cas.

How do we involve society/the social sciences?

The questions of where and when society and social sciences come into the picture, were discussed at length:

Regarding the involvement of society, it was emphasized that science and industry should engage in a dialogue with civil society as early as possible. It should be avoided to impose the technologies onto people. The technological developments are also likely to fundamentally transform the nature of employment, which brings about the question of education and training. A representative of the European Commission highlighted the public involvement in the entire decision-making process of the commission as an example in this context.

With regard to the inclusion of the social sciences, the participants and panelists agreed that the early integration of the humanities will be crucial for several reasons: (1) to build the trust of society; (2) to look at the demand/consumption side; (3) to analyze the potential of the biological transformation for addressing societal challenges such as achieving food security in the future; and (4) to analyze and stress possible social implications.

In addition to a stronger involvement of the humanities, the importance of the science-policy interface was emphasized.

What are disruptive developments of innovation/ new applications for traditional industries?

With regard to biotechnology, the importance of the field of DNA foundry was stressed and described as "totally a game changer" by some participants. In this context, the storage potential of DNA was particularly highlighted (e. g., 1 gram of DNA has the potential to store 3 million CDs).

On the other hand, the question was raised whether the potential of biology for the future of manufacturing is overestimated. How should the impact of biology in traditional industries such as steel, electrical engineering, automotive and other look like? In the following discussion, the panelists Markus Wolperdinger and Gerry Byrne gave examples, pointing out that the steel industry, for instance, can use biologicalization to make use of its by-products or the automotive industry can use it for its efforts to source sustainable materials. Another example is the current process of integrating biology into engineering devices in the medical device sector.

In this context, a workshop participant made the point that, in order to make use of potentials of biologicalization, existing preconditions and constraints are important. This is why it is so important to deeply understand and explain the development of biological principles (e. g., why has the flee the ability to jump that high?)

What´s next?

The workshop participants are cordially invited to participate in the Conference »Biological transformation of Manufacturing«, which is part of the conference series »FUTURAS IN RES« initiated by Fraunhofer; conference dates are June 28th and 29th, Berlin; website: https://futuras.fraunhofer-events.de/en/conference/ (responsible: Kerstin Funck, Fraunhofer-Gesellschaft, e-Mail: kerstin.funck@zv.fraunhofer.de)

Prior to the conference, on June 27th, the final results of the above mentioned study BIOTRAIN are going to be presented at Fraunhofer Forum Berlin; event title: »Biointelligenz – Eine neue Perspektive für nachhaltige Wertschöpfung«; language: German; website: https://biointelligenz.fraunhofer-events.de/

Policy
Measuring and Monitoring the Bioeconomy

Authors: Stefan Bringezu, Pedro Machado (Co-Chairs), Olivier Dubois (Rapporteur)

Abstract

The objective of the workshop was to address good practice examples, key concepts, critical measures and further development needs for monitoring the bioeconomy (BE). Three impulse statements introduced ongoing activities to monitor and assess BE in the EU, Germany and Brazil. About 100 participants in nine groups brainstormed to provide answers to the guiding questions. It turned out that good practice of monitoring and assessing the BE´s performance requires to (1) clearly define the objectives of BE policies (integrating civil society´s expectations), (2) take the SDGs as key reference, (3) develop a limited set of key performance indicators, scientifically valid while easy to understand and communicate, (4) apply both a territorial and a product chain (lifecycle of products) perspective, (5) provide measurements in a consistent manner across scales (country-international, country-regional-local, (6) improve transparency and cross-country comparability. Further research and international collaboration could help to (7) develop key performance indicators derived from a systems approach considering also trade-offs between objectives and undesired side effects of BE, (8) account for impacts both of biomass production as well as its use and consumption, (9) project important trends and model future paths towards more sustainable BE to enhance the evidence base for policies, and (10) consider implications of innovation and uncertainties. It became clear that increased exchange of information and international collaboration between experts, researchers and actors in industry and society is necessary to further develop monitoring and assessment of BE and broaden the understanding of benefits and risks.

Report

The workshop was introduced with three impulse statements presenting ongoing activities to monitor and assess BE. Andrea Camia from the Joint Research Center of the EU introduced the wide array of expectations associated with BE and presented research to develop monitoring at a European scale. Stefan Bringezu from Kassel University in Germany introduced an indicator system derived from policy goals (incl. SDGs) considering transnational impacts of production and consumption of biomass based products in countries (www.symobio.de). Danielle Torres from EMPRAPA in Brazil focused on the benefits of integrated crop-livestock-forestry production systems and pinpointed needs for further research.

Participants then addressed the following guiding questions:

1. What are the best practice examples to measure and monitor the impact of bioeconomy on society, environment, and economy, nationally, regionally and internationally?

2. Which concepts and tools should be used to improve measurement and monitoring of the bioeconomy in the context of the SDGs?

3. What are critical measures of assessing good governance in the bioeconomy for policy makers and civil society?

4. What further contributions of science and research are needed to enhance international cooperation and deliver key performance indicators?

For the discussion, the participants formed groups at nine tables. Each table was hosted by an expert moderating the session and a table rapporteur recorded the outcome.

The workshop was part of the GBS under the heading of good governance. Monitoring of good governance of BE, however, requires appropriate monitoring of the performance of BE which is still at an early stage. Therefore, the workshop focused on the latter. At the same time, it became obvious that the development of monitoring and assessment tools is part of a learning process which may help policies to adjust to newly observed challenges in order to enhance benefits and reduce the risk of undesired consequences of BE.

(1) Policy objectives.
Any assessment of BE requires a clear understanding of policy objectives. Countries and regions of the world differ in their expectations and priorities of BE. They range between better jobs and income in rural areas and shifts towards more renewable supply of resources. Also the coverage differs, while in most cases a biomass based production (and consumption) is implied, the inclusion of biotechnology and the application of biological principles in mineral based processes is still being discussed. When defining policy objectives of BE as a basis for monitoring, the expectations of societal actors would need to be considered.

(2) Benchmarking progress of BE towards sustainability.
For that purpose, the Agenda 2030 and the SDGs should serve as reference. When countries have already established programs to implement the Agenda 2030 and monitor progress towards this end, this might be the starting point also for BE monitoring. For some SDGs, trade-offs can be observed in the course of increased use of biomass resources (e. g. regarding water quality, biodiversity). Authority and legitimacy of monitoring systems will grow when those trade-offs are addressed and the risk of overlooking undesired consequences is minimized. Both socio-economic and environmental implications of the BE will have to be monitored, and indicators to be developed in areas where the SDGs are not yet adequately underpinned.

(3) Key performance indicators.
At country level, overview information is required to assess whether BE is developing towards a higher or lower degree of sustainability. For that purpose, a limited set of key performance indicators (KPIs) seems preferable; it should be linked to the major policy objectives, and underpinned by more detailed indicators and data. The KPIs should be evidence based and scientifically sound, reflect important features of BE, i.e. adequately consider complexity and portray key properties. At the same time, the KPIs should be easy to understand and communicate.

(4) Territorial and product-chain perspective.
Starting point of national monitoring is always the situation and trend within the own territory. However, countries are increasingly interwoven with international

trade, and the international sharing of resources and labor has led to growing trade flows. BE policies in one country may induce change in demand for biotic resources and have impacts in other regions of the world. Therefore, it is of paramount importance that the monitoring adequately considers cross-border impacts of BE, for instance by accounting for the land, water, material and GHG emission footprints of national consumption.

(5) **Cross-scale monitoring.**
Monitoring BE at the country level will have to be interlinked with information at other scales. The set-up of the indicators requires bottom-up data compilation. As the implementation of improvement measures requires action at the local level (companies, communities, households), the KPIs and their components need to be measurable not only at country level, but also at product and process level.

(6) **Transparency and comparability.**
Monitoring at country level should be transparent to enhance legitimacy, increase awareness of the people, and to support the use of the data by experts and research as well as in education. In order to allow comparability between countries, ideally a common set of KPIs should be developed. In addition to a common set, countries might provide indicators reflecting their regional specifics.

(7) **Systems approach**.
When further developing KPIs, a systems perspective will be important, to cover cross-sectoral and cross-country effects and to disclose trade-offs between objectives and undesired side effects of BE. For that purpose, a combination of life-cycle assessment methods with country statistics and spatial modelling seems promising. For example, monitoring resource and climate footprints of final consumption of biomass based products could cover cross-country and cross-impact effects.

(8) **Production and consumption.**
So far, BE opportunities have been mainly focused

on production of biomass in agriculture, forestry and fisheries and subsequent processing. Progress towards sustainability will require also more efficient use of biotic resources and advanced ways of final consumption. Thus monitoring progress towards sustainable BE will essentially require to account both for trends in production and consumption and related impacts.

(9) Trends and future development.
Monitoring usually starts with reporting past trends and status quo. At the same time, decision makers and the public want to know about the consequences if ongoing trends would continue and whether these would be beneficial or detrimental. Systems based modelling which covers essential cause-effect relationships and allows integrated assessment of BE may help to project important trends and model future paths towards more sustainable BE. Outlining desired futures, determining assessment criteria and interpreting the outcome of those projections should involve participation of stakeholders (research, industry, society).

(10) Innovation and uncertainties.
Technical progress and changes in demand pattern may drive production and consumption of BE products with unprecedented consequences. Opportunities and threats may arise which might be difficult to grasp in advance. When monitoring proceeds to include also trend trajectories and projections of future biomass use, this will require to consider uncertainties due to possible technological and institutional/regulatory developments. Uncertainties are also relevant for monitoring past trends and status quo, due to quality and variation of basic data. Exploiting various data sources, including crowd sourcing, and involving social networks and BE platforms may be helpful to support regular monitoring, up-date and cross-check.

What´s next?

- More research on systemic monitoring of BE is required in accordance with the 10 features listed above, in order to allow assessments of progress towards sustainable BE, and provide sufficient evidence base for policies and the public.
- More international exchange is needed on KPIs of sustainable BE in order to develop a common core set of KPIs for monitoring BE at country level, considering cross-sectoral and cross-country impacts, which may be complemented by country specific indicators.
- International and national policies should be informed via high level institutions such as G7/G20 on the need and opportunities to develop monitoring of BE and regular assessments of its progress towards sustainability.

Policy
Transformative Science and Communication

Authors: Achim Dobermann, Ben Durham (Co-Chairs), Susan Watts (Rapporteur)

Abstract

The phenomenal power of new technologies, including gene editing and synthetic biology, has the potential to transform society through innovative applications in agriculture, nutrition, and industry, amongst others. In order to harness such technologies for the benefit of the global bioeconomy, however, society must be supportive: there is thus a critical need to balance the applications with social licence, consumer acceptance, and ethics. The workshop provided short expert inputs on (1) the nature and power of gene editing, (2) the likely commercial outputs in the development of genetic engineering, (2) the current best practice in biosafety management and regulation, and (4) models for enabling translation to socially acceptable applications.

The following were identified as high level issues to address for harnessing such technologies:

- Break down barriers so there is more trust in science, by engaging with the public through multiple channels/approaches, where necessary involving professionals to craft evidence-based messages;
- Find ways to address the public's perception of risk;
- Find new, more effective, means of supporting the commercialization of publicly-funded research (as this is often of a more strategic, long-term, national nature); and
- Seek to ensure the technologies are both accessible to a wider pool of developers (through fair, reasonable and non-discriminatory principles), and result in products that are more directly relevant for the everyday consumer.

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Report

The workshop introduced the phenomenal power of new technologies, including gene editing and synthetic biology, which has the potential to transform society through innovative applications in agriculture, nutrition, and industry, amongst others. In order to harness such technologies for the benefit of the global bioeconomy, however, society must be supportive: there is thus a critical need to balance the applications with social license, consumer acceptance, and ethics. The workshop thus sought

to identify key challenges in securing societal acceptance in the harnessing of new technologies for bioeconomy purposes. Four impulse talks were provided to guide the participants towards the objectives of the workshop. They addressed the following questions:

- What are the nature, status, and prospects of genome editing, and possible regional differences for application of such technologies?
- Which genetic engineered products are most likely to be successfully commercialized and why?
- What are the critical social challenges that need to be addressed to guide and inform regulation, and increase public confidence?
- Are there new models for translation of publically-funded research that can be at least benign to the environment, useful to society, and help contribute to the Sustainable Development Goals (SDG)?

1

The first question was addressed briefly by Bekir Ülker (CEO, Agrojector). The difference between gene editing and selection, breeding, mutation, transgenics and cisgenics was briefly explained. The gene editing technology was pointed out as having low cost, being fast and efficient, applicable to all plant species, relatively simple to apply, and highly accurate.

Several examples of application of gene editing techniques were offered, including

- improved understanding of gene function,
- improvement of medicinal plants,
- improved agricultural characteristics,
- expression of therapeutics,
- food health benefits, and
- desired industrial characteristics.

Dr. Ülker presented a global map which showed the uneven distribution of gene editing activities, versus the opportunities and needs (such as disease and abiotic conditions) for such techniques. Further, he raised two concerns, relating to the complexity of the existing IP regime, and the need for regulatory development, to better enable global adoption.

2

Prof Johnathan Napier (Rothamsted Research) presented briefly on how synthetic biology and GM plants can help tackle some of the global challenges. He referenced the Sustainable Development Goals, and clearly elucidated the complexity of one of the goals, namely food security, which is not merely about production of food, but also nutrition. He gave the example whereby Omega-3 fish oils (with obvious nutritional and health benefits to humanity), a natural but limited resource, can be introduced into plants through the Omega-3 related genes, and can thereby assist in improving sustainable supply. He pointed out some other examples of modified crops that have consumer benefit traits, including anti browning in apples and mushrooms, and golden rice.

Prof Napier pointed out the length of time and cost for bringing a publically-funded technology to market. He noted (1) that the skills and experience of business/for commercialization are often absent in academia, (2) there is a need to inform policy makers and politicians on developments, and (3) he raised warning notes on the complexity of IP, and GM regulation.

3

Hennie Groenewald (Executive Manager, Biosafety SA) provided a short presentation on social conditions for a transformative bioeconomy. He pointed out that sustainability of transformative technologies will be based on both safety (both human and environmental factors), and viability (including both techno-economic and socio-political factors). He briefly outlined the current risk analysis process, which requires technical/scientific skills, but noted that because such a process occurs beyond public view, there is sometimes a crisis of trust.

Dr. Groenewald further noted that the public's perception of risk is often different/higher than that of the technical assessment, in part because of the public's limited understanding of the technical issues. He indicated that trust must not be assumed to be based simplistically mere knowledge, but has multiple dimensions, and that although transparency and consultation with the public is vital, it has limitations, and disagreements are inevitable.

For the transformative products to become reality, there is (1) a need to develop trust between the public and the developers and government's regulators, (2) society is an integral part of the innovation process and therefore good governance of product development is essential, and the perceived risk/benefit balance should be better communicated, and finally that (3) the products should clearly benefit the consumer.

4

Julian Kinderlerer (Emeritus professor, University of Cape Town, member: European Group on Ethics) presented a short overview of global developments with respect to the bioeconomy. He noted that the Brundtland report (1987) and the United Nations (1992) Agenda 21 both pointed out the increasing human impacts on the living planet and the need to harness technologies and change approaches to become more sustainable. The Sustainable Development Goals are one of the latest iterations, and an expansion, in such global efforts.

The investment in Science and Technology across the globe averages 2.04% of GDP, and is thus substantially, but unequally, resourced. It was noted that agriculture forms a higher percentage of income in poor countries, and there is a need to ensure the availability of high quality, high yielding crops across the world. To address the disparate needs across the globe, farmers in the developing world should also have easy access to the best seeds (for yield, nutrition, lowest need for pesticide/herbicide, etc), and IP issues would need to be considered to enable this.

Prof. Kinderlerer finally noted that much research is directly or indirectly funded through the public purse, and there is a need to ensure that benefits from the research are afforded to those who most need them.

The discussion that followed the presentations effectively reinforced the points made by the presenters. The harnessing of the technologies for the benefit of the planet will have substantial challenges to overcome – as learned through experiences with genetically modified organisms - and can be summarized as follows:

› In order to develop trust between the broader public and the protagonists of the new technologies, much more, and multi-dimensional engagement is required. This is to break down barriers to effective communication between the different publics (recognizing that scientists are a compo-

nent of the public), and thereby enable the public to have better insight into the motives/intentions of the developers, the benefits and risks of such developments, and the role of regulators in ensuring safe and feasible products that should benefit the public and the planet.

- The public's perception of risk is often substantially different from the technical risk as identified by experts, and this perception differential needs to be addressed (including through the communication approach identified above).

- A substantial portion of publically-funded research is strategic, long-term, and national or global in nature. As such, it can be of direct relevance to the SDGs and to global challenges such as the bioeconomy. However, the skills and support for the commercialization of such research is often lacking. New, more effective means of supporting and enabling the commercialization of publicly-funded research is required.

- To enable good governance in technology development and application, technologies need to be accessible to a wider pool of developers through fair, reasonable and non-discriminatory principles. Further, emphasis needs to be put on products that benefit the everyday consumer, whether by addressing issues of importance to the consumer (e. g. sustainability), or have direct relevance (e. g. more nutritious). For the purpose of bioeconomy development, the use of new technologies need to clearly link to resource recycling, sustainable use of biomass, sustainable livelihoods, and the broader SDGs.

What´s next?

To contribute to global resource sustainability and SDG's, bioeconomy proponents must be able to harness new technologies. Such a process is challenged, however, by the substantial hurdles of obtaining social support and license. The workshop identified some key issues that will need to be considered and addressed, and further work on approaches and guidance need to be detailed on how proponents of bioeconomy developments should consider seeking social acceptance.

Policy
International Cooperation in Education and Training for the Bioeconomy

Authors: Ahmed Fahmi, Josef Glössl (Co-Chairs), Ulrich Schurr (Rapporteur)

Abstract

Research, innovation and education at all phases of the professional career form an indispensable basis for the development of sustainable bioeconomy concepts (Global Bioeconomy Summit 2015). There will be no “one-size-fits-all concept” of the bioeconomy. For the specification of the different job profiles of human resource base for the bioeconomy, the diversity of circumstances and requirements in different regions and macro-regions in developing, emerging and developed economies have to be considered. Educational curricula provided by universities and vocational institutions have to meet the demands of the employers in the various bioeconomy sectors. This requires an interdisciplinary approach that emphasizes systems thinking, strategic planning, economic performance, and evaluating environmental, ethical and social issues. In addition to focusing on the natural, technical and social sciences, the curricula should also develop entrepreneurial skills in preparing graduates for management roles to develop and grow new ventures in the bioeconomy. These developments require collaboration between universities, industry and policy and governance stakeholders. There is also the need to raise awareness of bioeconomy in primary and secondary education.

Key topics of the workshop were (i) the demands for knowledge, skills and competences for the bioeconomy, (ii) the need for innovation in the current concepts of bioeconomy education and (iii) the need to increase and/or strengthen the cooperation between educational institutions. Therefore, a further aim of the workshop was to provide a basis for the development and implementation of a “European/International Bioeconomy Education Platform”, representing stakeholders from academia, industry, society and public administration. International measures need to define the knowledge, skills and competences required for developing a bioeconomy that enhances the sustainable use of biobased materials in manufacturing and in consumer products.

Report

Research, innovation and education at all levels form an indispensable basis for the development of sustainable bioeconomy concepts (Global Bioeconomy Summit 2015). There will be no "one-size-fits-all concept" of the bioeconomy. For the specification of the different job profiles of the bioeconomy human resource base the diversity of circumstances and requirements in different regions and macro-regions in developing, emerging and developed economies have to be considered. Educational curricula provided by universities and vocational institutions have to meet the demands of the employers in the various bioeconomy sectors. For universities, this requires research-based training with an interdisciplinary approach that emphasizes systems thinking, strategic planning, economic performance, and evaluating environmental, ethical and social issues. For vocational training and training on the job, the diversity of practical needs is huge and efficient solutions need to be built into existing approaches. In addition to focusing on the natural, technical, economic and social sciences, the curricula should also develop innovation and entrepreneurial skills in preparing graduates for management roles to promote changes in existing industries, but also to develop and grow new ventures in the bioeconomy.

These developments require collaboration between universities, vocational training organizations, industry and policy and governance stakeholders. International cooperation can bring additional momentum and requires accepted standards in order to benchmark and sustain these initiatives for the future. It is important to understand, which are the optimal instruments (e. g. qualifications, quality assurance, mobility, accreditations, fellowships, grants and scholarships, etc.) that need to be put in place for an effective workforce for the bioeconomy sector.

In addition to targeting curricula at university and vocational training level, there is also a need to create hubs or centers of excellence/competence in bioeconomy which can represent desired models of operation. Here, the triangle of research, education and training can grow in a way which is fostering integrative approaches by addressing the relevant stakeholders representing the different fields of the bioeconomy; whether this is in the production of biomass (e. g from agriculture, aquaculture, forestry), and its use in the food value chain or in the non-food value chains (e. g. energy, pharmaceuticals, health). Concomitant with these efforts, a campaign raising the awareness is needed to reach out to educational and training activities in the entire life-long training cycle to showcase the objectives of the bioeconomy and what it entails.

Aims of the Workshops

The aims of the Workshop were:

- To provide an input to the updated EU Bioeconomy Strategy which should put emphasis on (i) the demands for knowledge, skills and competences for the bioeconomy, (ii) the need for innovation and entrepreneurship in the current concepts of bioeconomy education and training and (iii) the need to enhance the cooperation among educational and training institutions as well as with their stakeholder (e. g. industry, public governance), and (iv) establishing centres of excellence/competence on education, research and training dedicated to the bioeconomy.

- To provide a basis for the development and implementation of a "European/International Bioeconomy Education Platform" representing stakeholders from academia, vocational training

institutions, industry, society and public administration. This platform needs to be included in the EU Bioeconomy Strategy and its Action Plan (as initially proposed in the Lodz Declaration on a European Bioeconomy Education Platform, 2017).

Guiding Questions and Outcomes

As a basis for further discussion, representatives from the three stakeholder groups universities, industry as well as policy and governance gave input statements from their respective points of view. In seven parallel discussion groups (in a modified world café format), the key points of the speakers were reflected and three different sets of Guiding Questions were discussed.

Guiding Question 1:
What are the current deficiencies in the curricula approaches (knowledge, competences and skills for cross-disciplinary understanding) in education and training institutions related to the bioeconomy in developed, developing and emerging economies? Which new approaches are required in education and training for growing a sustainable bioeconomy?

Outcomes:

- Proper and careful, sustainable use of renewable resources needs a future generation of researchers and practitioners in all relevant sectors with consolidated knowledge and deep insight into the living and nonliving world and natural cycles.

- Education beyond disciplinary curricula, in particular in inter- and transdisciplinary competences, is required. The implementation of a sustainable bioeconomy needs skillful workforce who are used to think critically and act in an interdisciplinary and transdisciplinary working environment. In addition, skills in project management, leadership, communication, transformative thinking and cross-cultural/cross-silo-thinking must be key components.

- In order to cover the urgent needs for education in bioeconomy, both the adaptation of existing curricula, e. g. in life sciences or technical/engineering programs as well as the development of new curricula dedicated to bioeconomy will be required. Perhaps the biggest developments are required in the non-food value chain and for interlinking the food and non-food value chains, for assuring a sustainable, circular bioeconomy.

- Implementation at all career stages must be in alignment with stakeholder demand. Careerpaths should be followed in different institutions/companies. Industry should offer internships, development of tandem training models (academia – industry), including training of teachers.

- Start education on bioeconomy at early stage to show opportunities at all levels.

- Study program should combine natural sciences, economics, social sciences and engineering, providing knowledge for an ecologically and economically sustainable use of natural resources.

- Students and graduates should be aware of the necessity to merge the guiding principles of sustainability and entrepreneurship in developing and implementing bioeconomy concepts.

Guiding Question 2:
Are new human resource and institutional capacities needed in education and training institutions for

providing the workforce for a growing sustainable bioeconomy? How can these be created? What are the resources that the public and private sector can contribute to building such a model of the bioeconomy?

Outcomes:

- There is an increasing demand for qualified human resources with integrated multidisciplinary knowledge and skills at all levels, including vocational education and lifelong learning offers (training of employees on the job), covering a wide range of scientific, technological, social and economic domains. Education and training programmes should be designed to cover all target groups, including the farming sector.

- There should be more cross-disciplinary trainings and joint degree programs, for example, to enhance the abilities of future business leaders to manage research-driven enterprises, and to enhance the business and entrepreneurial skills of scientists.

- To build human resources needed to drive the bioeconomy, there is a need to strengthen cooperation not only among educational institutions but also between educational institutions, research institutions and industry (as each has its own profile and strengths that can complement each other) both, within and across countries.

- Ensure education for excellence in the specific field. Based on this, training should be in real life/industrial context to get used to look beyond the limits of expertise (e. g. using job rotation within/between companies, academia/industry/research institutions).

Guiding Question 3:
How can synergies be developed at regional and/or global levels to support the capacity building of education and training institutions for growing a sustainable bioeconomy?

Outcomes:

The workshop provided an improved basis for mutual capacity building for the implementation of bioeconomy concepts at the European and international level.

- Utilize university network, students initiatives and industry networks for building synergies.

- The regionality is linked to tax systems, the IP framework and regulatory aspects, all the rest can be seen as global.

- Education of citizens about bioeconomy and biobased products has to be strengthened and be continuous in order to raising awareness on bioeconomy.

What´s next?

- Development of a „European/International Bioeconomy Education Platform" with a global perspective to provide a forum for international collaboration and exchange on education and training at all levels for the bioeconomy.
- Map bioeconomy education at all levels of career.
- Development of joint activities based on existing university and industry networks as well as international organizations (e. g. UNESCO), in close cooperation with the European Commission.
- A stakeholder workshop at European level and link it to global activities as a forum for exchange, and for input to policy makers will be organized by the workshop planning group in 2019.
- Take action now! Developing education for bioeconomy is urgent. There is already a shortage of key competences and demand is expected to raise quickly.

Innovation & Environment
Biodiversity for a sustainable and thriving Bioeconomy

Authors: Maritta Koch-Weser, Johannes Vogel (Co-Chairs), Johannes Vogel (Rapporteur)

Abstract

The workshop discussed opportunities and approaches to build a more vibrant bioeconomy which is (i) delivering the necessary systemic change towards a sustainable global economy and (ii) designed to protect nature. We reflected on the opportunities and challenges ahead to realize this, the necessary framework conditions, and feasible approaches and solutions. Many stakeholders need to coordinate their activities and efforts in order to achieve progress. Biodiversity science, development, training, policy, and finance communities must align approaches in order to accelerate change over the coming years.

Report

The workshop was inspired and driven by three major guiding questions:

1. How to create biodiversity knowledge that makes a tangible contribution for nature protection?

2. How to implement a sustainable bioeconomy at all levels from local to global?

3. What kind of governance framework is needed to drive the transformation towards a sustainable bioeconomy through biodiversity knowledge?

A tour de force through the wide field covered in this workshop was provided by seven short scene-setting introductions to its various aspects:

- Harnessing biodiversity knowledge as an open global resource (Thomas von Rintelen & Johannes Vogel)
- Making Research Matter for Nature Protection (Ismael Nobre)
- Biomedicine Prospecting (Shamsun Khan)
- Biodiversity and the future of global health (Simon Elsässer)
- Biorefinery (Volker Sieber)
- Nature Cosmetics, Amazonia (Maria Beatriz Martins-Costa)

› Bioeconomy at Community-Level: Farm models, infrastructure, finance & market access, regulatory environment (Maritta Koch-Weser)

These talks clearly showed the enormous potential of building bioeconomy on the direct sustainable utilization of biodiversity, but all speakers also indicated the steep challenges faced, which range from basic research data mobilization by biodiversity science to questions of governance and the economic viability of taking a sustainable approach to the utilization of living resources rather than traditional exploitation.

Following the impulse talks, round table discussions were set up to discuss the opportunities and challenges we are facing to achieve the aim of building a truly sustainable and vibrant bioeconomy based on biodiversity science. The number of round tables was reduced to three (see below) to focus on the most crucial aspects. Taking into account the preceding presentations, topics discussed ranged from the very question of what sustainability is to the creation and mobilization of biodiversity knowledge for nature protection and the applied field of biorefinery. Thus, building blocks for establishing the framework conditions and consequently viable approaches and solutions were identified.

Sustainability definitions & monitoring – the Achilles Heel of Bioeconomy?
(Discussion leader: Harald Schneider)
Resumee: Sustainability has social and environmental aspects, which need to be aligned. Economic growth, job security and hunger reduction all require preservation and innovation: all these issues encompass huge societal challenges. The exploitation of natural resources needs to be monitored in order to keep the exploitation sustainable. Traditional knowledge must be included more effectively. The development of new chemical products requires knowledge about plant genomics and pharmacogenetics. Economical interest should not take precedence over human safety.

Academic perspective: How to create biodiversity knowledge that makes a tangible contribution for nature protection?
(Discussion leader: Olman Madrigal)
Resumee: Focussing on the Amazon, information must be mobilized by joining the museum network in order to collect past historic and cutting edge knowledge as a starting point (common responsi-

bility). At the local community level, awareness of indigenous knowledge about nature must be raised and collected; indigenous people must be brought into the core of the initiative through working with communication experts. An Amazonian cooperative system between people, research and development and the national regulation agency should be developed. This Amazonian cooperation could organize the trade with the market.

Biotools – how can biodiversity help for technology development?
(Discussion leader/rapporteur: Volker Sieber)
Resumee: Biodiversity is not confined to (tropical) forests, but also diversity on the field (insects, plants, etc.); agroforestry and landscaping are thus suitable approaches. A major challenge is achieving economic efficiency, though: just getting valuable compounds from plants is good, but will not make a change, as large amounts of biomass needed. Biorefineries thus have to join ecosystem services. New technologies for better, complete utilization (heterogenous substances) and waste utilization must be further developed. All approaches should help politics to safe biodiversity by bringing technologies to local people to help them gain a living and getting value from the sustainably utilized field. Conflicts between economics and sustainability should be avoided by increasing value with conversion technologies for new products; involve e.g. NGOs in order to support the local people so that they can apply those new technologies.

A key outcome of the workshop was the identification of the most pressing challenges on the way to implementing a biodiversity-based sustainable bioeconomy:

- A massive increase in knowledge and research efforts is needed
- 'Big data', other IT innovations and AI must be fully utilized to this purpose
- Sustainable knowledge networks must be created in order to
- facilitate knowledge transfer to the global public.

What´s next?

Important global measures:

- Turbocharging Biodiversity Discovery & utilize new technologies
- Enable broad participation (local/ NGO)
- Increase engagement with public
- Equitable sharing & monitoring

One major outcome is the build-up of the Amazon Third Way program, which foresees capacity building and research in the Brazilian Amazon, and establishment of the world's first Rainforest Business School. An incubator for the program is located with the Institute for Advanced Studies at University of Sao Paulo (USP), Brazil. The program is focused on building a new competitive bioeconomics based development paradigm for Amazonia.

Innovation & Environment
Blue Growth: Seizing new Opportunities for a Sustainable Future

Authors: Bjørn Tore Erdal, Alejandro Mentaberry (Co-Chairs), Alit Fasce Pollicelli (Rapporteur)

Abstract

Marine biological resources represent a huge economic asset that, apart from commercial fisheries, remains largely unexplored. On the other hand, human activities and global climate change increasingly impact and threaten many marine ecosystems and species and are a serious threat to the survival of many species. Introduction of sustainable practices in the blue bioeconomy and permanent monitoring of marine populations and ecosystems are clearly needed and require close international cooperation.

This workshop aimed at contributing to the international discussion on blue growth and sustainable management of marine resources.

The workshop was divided into two sessions, i. e. “marine aquaculture” and “disruptive trends in blue bioeconomy”. The present status of sustainable blue bioeconomy, marine aquaculture and future trends emphasizing scientific and technological achievements were presented, and socio-economic issues involving international cooperation were highlighted.

Report

MARINE AQUACULTURE

Technology and Nutrition
Margareth Overland, Norwegian University of Life Sciences, Norway

Marine aquaculture has seen a tremendous growth over the last decades. However, limited access to marine ingredients and large dependence on imported feedstuffs call for the development of novel protein sources. Blue and green biomass can be used to produce new feed resources with novel technology. Extensive research is now advancing the technology to develop cost-efficient microbial feed resources, such as biorefinery processing turning biomass from wood and seaweeds into yeast. Continued R&D can be an important contribution to securing an environmentally and economically sustainable marine aquaculture in the future. In order to realize this potential, more international collaboration between researchers, public authorities and the industry is warranted.

State-of-the-Art in Mussel Cultivation
Angela Schultz-Zehden, Submariner Network, Germany

Depending on the cultivation region, most mussels cultivated in the Baltic Sea grow quite slowly and therefore are too small for human consumption. Mussels are absolutely necessary to reduce the particle and eutrophication level of this ecosystem, but the result is a huge amount of biomass with no economically relevant application. One feasible solution might be the production of mussel meal, which can be used as an additive for animal feed, e. g. aquatic species, as fish and crustaceans.

Multitrophic Farms
Thierry Chopin, University of New Brunswick, Canada

Multitrophic farms involve polyculture with diverse species in the same food chain. The recommendation is that we should not make the same mistakes with monoculture as seen in common land-based agriculture. Today, the typical regulation is made for monoculture production. The upcoming challenge will be the integration of species from different trophic levels in future aquaculture systems and to make this the common approach for improving the aquatic bioremediation process. To calculate the full value of integrated multi-trophic aquaculture, extractive species need to be valued for not only their biomass and food trading values, but also for the ecosystem services they provide, along with the increase in consumer trust and societal/political license to operate they give to the aquaculture industry. Multi-crop diversification could contribute to diversifying the portfolio of seafood products as well as addressing climate change and coastal acidification.

Argentinean Aquaculture
Alit Fasce Pollicelli, Ministry of Science, Technology and Productive Innovation, Argentina

Argentina is a country that sells more fish than beef to the world. Despite having quantities and top quality natural resources to develop aquaculture, there is no marine aquaculture in this country. To develop this activity, the government is working with other governments and signing agreements with international institutions to work on regulatory and multi-trophic pilot plants. This country is open to working in collaboration with other countries and institutions.

Demonstrating Mussel Farming in the Baltic Sea
Efthalia Arvaniti, Submariner Network

The Submariner Network is a network of projects including: Baltic Blue Biotechnology Alliance (focus on the development of marine bio-based products), Baltic Blue Growth (Initiating full-scale mussel farming in the Baltic Sea), SmartBlue Regions (Smart Specialization and Blue Growth in the Baltic Sea Region) and InnoAquaTech (cross-border development and transfer of innovative and sustainable aquaculture technologies). Baltic Blue Growth is a project that started in May 2016 and will finish by

March 2019. It has a budget of €4.7 million and involves 18 project partners from six countries and six pilot farms. Its main objective is to obtain an advance mussel farming in the Baltic Sea from experimental to full scale to improve the water quality and create blue growth in the feed industry. Mussels grow naturally in the Baltic Sea without extra feed or fertilizer and it can be combined with other types of aquaculture. Mussel production provide important ecosystem services and is also driving blue growth in terms of feed and food and has positive impacts on tourism and contributed to circular economy and job creation.

DISRUPTIVE TRENDS IN THE BLUE BIOECONOMY

Marine Biotechnology
Simone Cappello, National Research Council, Italy

Marine Biotechnology has become a multi-billion industry worldwide, with constant growth expected during the next years. The impact of this new field would lie in discovering new pharmaceutical and biomedical applications, life science products for industry and new types of energy. It has direct impact on the environment, for its protection and management in bio-stimulation and bio-augmentation. In terms of food, it may result in the development of new food products and ingredients of marine origin, for example, new bacteria and algae, and new invertebrates.

Micro- and macro-algae for food, feed, and fuel
Olavur Gregersen, Ocean Rainforest, Faroe Islands.
State-of-the-art of marine aquaculture: the culture systems for protected zones are currently well-developed, including seeding, for sheltered and exposed sites (nearshore and offshore). Downstream processes, like pre-treatment of biomass and biorefinery (co-extraction), are well-developed, but at lab-scale.

Regarding markets, there is an increasing interest in food, feed, and new components for cosmetics. Finally, the community has a better understanding of environmental impact assessments (negative and positive).

In terms of biomass production, seaweed has more capacity to grow than any crop culture on

land, with growth rates of 26 Tn/ha. The disruptive trend is documenting the healthy nutritional and environmental functions of macro-algae in food, feed, and others. A biorefinery approach on a pilot scale and producing a biodegradable textile are demonstrated as examples.

Disruptive Trends in the Bioeconomy - From "Waste" to Value
Hordur G. Kristinsson

Biobased ingredients are highly demanded, for example, dietary supplements represent a USD 90 billion market, increasing at a rate of 6-7%. Sports nutrition represents $7 billion in the USA, which is 83% of the global market, with a 13% growth. In that same country, functional food represents $37 billion. Beauty and personal care is a $433 billion market with a 4-6% annual growth.
But if we analyze where food came from, it turns out that 71% of the earth's surface is covered by water, but only 4% of global food production is derived from the seas. Seas are not yet an exploited source of food, though it could supply new components and molecules to answer the increasing demand for biobased products.

Nowadays, markets are undergoing transformation, with the pharmaceutical and tourism markets converging in consumer's health care products.

The main idea is to work in a diverse blue biorefinery to obtain new biobased products from the fishery and aquaculture industry, adding value to the discarded biomass produced during fish processing.

Small is beautiful
Tim Staufenberger, Kieler Meeresfarm GmbH, Kiel, Germany

Kieler Meeresfarm cultivates macro-algae and mussels in Kiel, Germany. Whereas many industries focus on company growth and year-round availability, Kieler Meeresfarm has focused its business model on small quantities of high-quality products. Regarding the production of mussels, this entails that their products are only offered during parts of the year. On the other hand, the mussels are certified organic and can arrive at the market only five hours after being harvested.

Regarding the macro-algae products, the production is 100 kg per year and is sold to the cosmetic sector.

Questions from workshop participants

› Seaweed culture: Could there be an automatic system to produce it offshore?

Today, there is a limit in the scale-up, but an idea of floating systems could probably work. There are some systems working in the USA to produce biofuel.

› To Tim Staufenberger: Why do you sell your product on Amazon? Is this not contradictory?

No, because it helps with publicity, and he only sells in a limited area. So, Amazon does not let you buy until you are within a certain distance from the farm.

› In IMTA culture: How near should the species be?

The species should interact with each other by sharing nutrients, but there is not a biological minimum limit. By law, the limit is about 300 m in Nordic countries and in Canada.

› To all the panelist: How much does each project cost?

Thierry Chopin said that their project costs 12 million dollars. Other projects are in the scale-up phase, so each step is paid by diverse founds. They are not sure what the whole project costs are.

› To Thierry Chopin: Where is the bottleneck in IMTA farm development?

Regulation: the policymakers have no idea about how to manage a multicultural system or how to develop the adequate regulations either.

What´s next?

There are many new initiatives but almost all could be summarized in the same three pillars:

Farming
Farming should be done multitrophic and seaweed is essential for these systems. These systems can be used to clean areas and fix carbon dioxide.

Biorefinery
Intersecting sectors from green to blue biorefinery technologies, and scaling up these biorefineries developed at lab scale or in a pilot plant.

Products
New products are developed by using marine biotechnology technologies, e. g. food products (smart food, nutraceuticals), feed (to produce food in a more efficient and environmentally friendly way) and health care, cosmetic and cleaning products with less impact on the environment.

All these initiatives are being developed as collaborative projects. This workshop helped the participants to link the initiatives, and we are optimistic that this will result in cross-collaboration between them.

Innovation & Environment
Bioeconomy, Health, and Climate Change

Authors: Andrew Haines, Jos Lelieveld (Co-Chairs), Jos Lelieveld (Rapporteur)

Abstract

Although bioeconomy and public health are closely linked, these linkages have, until now, gained relatively little attention in bioeconomy policy agendas. This workshop addressed the effects of policies in different sectors on public health and the environment and opportunities for the mitigation of environmental change arising from a sustainable bioeconomy. Recent research has highlighted the significant contribution of current practices in agriculture and forestry to air pollution and climate change, in addition to the established contributions of sectors such as energy and transport. Policies to reduce these emissions will therefore not only slow down climate warming but at the same directly benefit public health. Additional risks for public health emerging from food production, especially from animal husbandry, are the potential spread of infectious diseases and the formation of antimicrobial resistance. Furthermore, nutrition-related health outcomes are of increasing concern with two contrasting challenges: on the one hand, after decades of progress, the number of undernourished people in the world is rising and on the other hand, obesity and other diseases related to over-consumption are spreading in many countries. In this workshop, experts set the scene with brief presentations, followed by an interactive session in which participants worked in teams to identify the most promising approaches and solutions illustrating how policies to support the bioeconomy can positively contribute to public health and environmental sustainability including to progress towards the Sustainable Development Goals, by addressing for example, health, nutrition, agriculture, energy and cities.

Report

In view of the great challenges ahead, it will be crucial to address issues of public and environmental health in bioeconomy policy and innovation agendas. As Sir Andrew Haines stressed in his presentation, urbanization will be a key driver of future resource use, emissions and pollution-related diseases. On the one hand it creates an increasing need for housing, transport, food etc. and, on the other hand, residents in many locations are increasingly exposed to the pollution caused by these sectors. The impact on public health is tremendous, especially in the cities of the emerging economies. Climate action to cut emissions of climate active pollutants will help to prevent diseases and premature deaths caused by pollution as well as reducing the risks of climate change. A

low-carbon bioeconomy might contribute in several different sectors, e.g. by providing more sustainable and resilient buildings, by closing organic material cycles (biogas from organic wastes), by offering innovative solutions to greening cities and cleaning the air and by enabling fresh food production in or near to cities.

Bioeconomy however is not a solution to climate change and health issues per se. The traditional sectors of bioeconomy, such as agricultural and food production, are causing significant pollution and further climate change, which in turn increases the risk of biodiversity loss and promotes the degradation of previously fertile soils, especially in poorer regions of the world. About 90% of the world´s population is breathing levels of particulate matter higher than the guideline concentrations of the WHO. Jos Lelieveld presented results of recent studies which reveal that in many parts of North America, Europe and East Asia the air pollution resulting from agricultural production can be larger than that from the traffic sector. Agricultural practices need to adopt measures, such as sustainable land management, cutting fertilizer usage and, at the same time, reducing consumption of animal products in high consuming societies, in order to significantly cut emissions and restore vital ecosystem services for the sector.

Alisher Mirzabaev illustrated how interactions between land degradation and climate change impact on human health. Land degradation under changing climatic conditions aggravates hunger and malnutrition. The resulting impacts are especially harmful for the healthy development of affected children. Moreover, human activities have considerably increased the frequency and scales of rangeland, forest and cropland fires, both contributing to climate change and human disease burden due to the air pollution. Increasing aridity under climate change amplifies the frequency, intensity and scales of dust storms, which represent a substantial cost to human health. There are numerous technological and policy solutions available that could help avoid, reduce and reverse land degradation. Supportive policies are needed for their wider adoption. Sustainable land management can provide multiple-win-win solutions contributing to climate change mitigation and adaptation, with considerable co-benefits, including in terms of human health.

With a view to the role of food and nutrition in bioeconomy, health and climate policy, the workshop highlighted several key drivers. With increasing middle-income classes, many of the emerging economies are increasingly converting to Western diets, characterized by an unhealthy or at least unnecessary over-consumption of animal products. Graphs shown by Hannelore Daniel impressively illustrated how the growing world population's rising demand for meat and animal products will further increase the pressures on food production systems and put environmental and public health at risk. Greenhouse gas emissions as well as land and water use could be significantly reduced, if recommended guidelines for a healthy diet (for example published by the WHO) were followed. And the co-benefits for environment and public health would be a lot stronger if meat consumption was further reduced and a diet rich in plant–based foods became more common. In her talk, Hannelore Daniel also acknowledged the inefficiencies of the current production of high-quality protein through livestock. Alternative protein sources present an opportunity to overcome those inefficiencies and the associated over-use of natural resources.

Hanna Tuomisto provided an overview of new developments in alternative protein sources and introduced the concept of cellular agriculture. Instead of growing whole organisms, such as plants and animals, cellular agriculture utilizes cell-culturing technologies to produce food and materials. The products from cellular agriculture can consists of the cultivated cells or can be compounds synthesized by microbial cells. Cultured meat, for example, is produced by cultivating livestock muscle cells in a bioreactor, whereas biotechnologically engineered yeast or fungi can be used to produce milk or egg proteins. Such products bear great potential for more sustainable nutrition because the inefficiencies and environmental pollution associated with producing animal products by conventional animal husbandry could be avoided. Greenhouse gases produced by these processes could be a fraction of those from protein production through livestock, if the production processes can be scaled up in an efficient way. Also, less water, energy and land would be needed. Biotechnology can also be used to give meat substitutes a more meat-like taste, texture and smell. Together with plant-based meat alternatives, cellular agriculture could therefore significantly contribute to a more healthy and sustainable food system. However, Tuomisto emphasized the need for rigorous Life Cycle Analysis of innovative technologies to ensure that the claims of environmental benefits were based on firm evidence.

Overall, the impulse presentations and the following lively discussions between the participants yielded an intensive exchange of knowledge and opinions. Links between bioeconomy and public health were seen as a highly relevant topic, both from a global sustainability perspective and a bioeconomy policy perspective. Especially the dynamic relations and inter-dependencies between modern lifestyles, bioeconomy, climate change and public health were considered of global importance, however, with different local patterns or implications. It was concluded that three major trends play an important role in this context:

- Urbanization provides a huge opportunity for sustainable bioeconomy solutions in the building, traffic, energy and nutrition sectors.

- Unsustainable land use and land degradation amplify health impacts from climate change and restoring soils can help to address these effects.

- Shifts in diets with low environmental footprint and innovative technologies could have a huge impact on food systems, which already contribute significantly to climate change. Well-designed policies have the potential to address the interlinked challenges of providing healthy food for a growing world population whilst reducing the environmental impacts of food systems.

What´s next?

The workshop provided a first overview discussion of how bioeconomy can contribute to improving public health particularly by restoring ecosystems incl. soils and by low-carbon policies to reduce air pollution. The growing importance of public health in climate policy could support bioeconomy policy agendas. Participants concluded that rigorous assessment of health and environmental impacts are urgently needed. Evidence-based solutions have to be communicated effectively. Three main messages emerged from this workshop and can be taken as recommendations for future bioeconomy policy agendas:

- Healthier diets including increased consumption of plant –based foods should be promoted globally, because they use much less resources and emit much less greenhouse gases than the animal protein-rich western diets.
- Bioeconomy provides technologies and policy options for more sustainable cities as well as food systems, but they have to be actively implemented.
- Integrated strategies for climate mitigation and adaptation are needed to achieve health co-benefits in the bioeconomy.

World Bioeconomy Exhibition

GBS2018 Exhibition Report

Bioeconomy is key to achieving all of the seventeen Sustainable Development Goals (SDGs)

In particular the SDGs 1 & 2 (Zero Hunger & Good Health and Well-Being), SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action). For this reason, the Global Bioeconomy Summit 2018 was flanked by a world exhibition – divided in four pavilions filled with 85 exciting bioeconomy products from 34 different countries. H.E. Anja Karliczek, the Federal German Minister of Education and Research, was one of the prominent visitors and visibly impressed by the variety of innovative solutions.

With a view to fighting hunger and malnutrition, for example, bioeconomy provides innovative products made from residues and food waste, novel sources of probiotics and essential nutrients, but also biobased medicines and care products.

With a view to climate action, bioeconomy involves renewable energy, using CO_2 as a feedstock and low-carbon production. Exploring algae as an alternative source of energy and food is one approach, using lightweight and renewable materials in sustainable transport, another.

Biobased solutions contribute to sustainable industrialization and innovation. 3D printing, for example, is enabled by biological materials and bio-inspired structures. Biodegradable packaging materials can be grown from mycelium or produced from starch. High-tech materials, such as break-resistant smartphone displays and waterproof textiles, can be biobased, non-toxic and renewable.

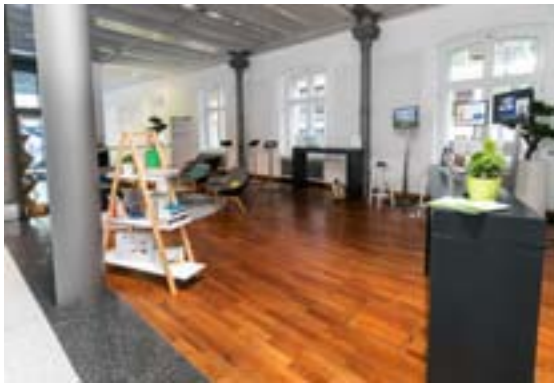
To encourage sustainable consumption, green brands develop many creative products that range from vegan leather bags based on residual pineapple leaves to dresses made of wood fibers and stationery items produced from local elephant dung or meadow grass.

Media Corner

Media Corner

Communication is essential to creating the basis for a better understanding of the bioeconomy, to captivating with its biobased innovations and to triggering thinking about a more sustainable way of living. In the GBS Media Corner, visitors could use the breaks in the conference program to take a seat and read the latest bioeconomy books and brochures, watch videos on three different screens, play games on tablets or try out new communication tools such as virtual and augmented reality.

After the first plenary session, the Media Corner quickly filled with interested people. They chose books from the shelves and tables and could sit down to read educational textbooks for students and scientists or popular science books on bioeconomy-related topics. Books about cooking with sustainable protein sources, such as insects and algae, were a special feature. Many visitors also found the easy-to-read cartoons and graphic novels a welcome change.



Others opted to pick up the headphones and watch the screens. Movies clips were shown in three categories: On the first screen, bioeconomy around the world introduced different national strategies and approaches for the transformation to a bioeconomy. The second screen showed some examples of new bioeconomy education programs and courses, while on the third screen visitors could follow a compilation of clips explaining what bioeconomy actually is.

Many visitors chose to play entertaining online games on the three tablets installed in the Media Corner, testing their knowledge of biobased materials and sustainability at the same time. Board and card games were also displayed.

Leaving the real world behind, visitors to the GBS Media Corner could put on virtual reality (VR) headsets to watch a 360° movie about Iceland's bioeconomy made by Matís. It will be exciting in the future to see this relatively new tool used in new applications for bioeconomy education and outreach. Interactive VR-applications, enabling users to actively intervene in a bioeconomy setting, will be the next level up.

Finally, a customized augmented reality (AR) application revealed previously invisible visuals if the tablet was held in front of one of the pictures: A biogas plant appeared in a wheat field and a Petri dish on a lab table. A bioeconomy movie started when it was held in front of another picture. Thanks to AR, the last picture of a polluted city turned into a futuristic green biocity.

We used a variety of tools in the GBS Media Corner to show that bioeconomy can be successfully communicated to different target groups and the public.

Lists of the material displayed in the Media Corner are available at: https://gbs2018.com/resources

Bioeconomy Art Competition

Bioeconomy Art Competition

In order to involve young people from around the world in the Global Bioeconomy Summit 2018 and to gather their visions of a future bioeconomy, students from all disciplines were invited to submit creative artworks that address one of the following questions:

1. What is your vision of a future bioeconomy?

2. How would you like to live in the future and how would bioeconomy contribute?

3. How will the bioecownomy contribute to coping with global challenges in your direct living environment?

The Conference Secretariat received more than 20 entries which were evaluated by a jury. The jury selected three competition winners based on a series of criteria (including thematic consistency, innovation, originality and creativity).

The jury was composed of:

- the art professor and illustrator (Hans Baltzer)
- representatives from the German Bioeconomy Council (Holger Zinke & Hannelore Daniel) and its Secretariat (Christin Fund),
- and the young international bioeconomy scientist Helen Berga.

The winners of the competition got the chance to participate in the GBS2018 and to present their work to an international and expert audience.

The results of the competition were exhibited during the GBS2018. They will feed into the discussions on future visions of the bioeconomy and how these visions can be communicated to different audiences.

Bioeconomy Art Competition

The three winners

My name is **Alexis Stylianou** and I come from Cyprus. For as long as I can remember, I've always had a passion for painting and drawing. I went to an English-speaking high school and graduated in 2013. For the next two years I served in the Cypriot Army. After finishing my military service, I moved to Berlin to study. I spent a year learning German before starting my studies in Visual Communications at the University of Applied Sciences Europe and I am currently in my fourth semester. My studies provide me with the scope to grow creatively and experiment with different kinds of media.

Tali Teper is a 24-year-old visual communication student at the Bezalel Academy of Arts and Design in Jerusalem. She specializes in art direction, illustration, motion design, interactive and concept design. In Summer 2017, she took part in a student exchange program at BTK – Art & Design in Berlin, which is part of the University of Applied Sciences Europe. Ms. Teper is currently living and working in Jerusalem, Israel.

Alex Giurca is a PhD student within the BBW ForWerts Graduate Program and works for the Forest and Environmental Policy Group at the University of Freiburg (Germany). Before coming to Freiburg in 2015 he studied, worked in and hiked around many forests in Finland, Sweden, Brazil, and Romania. His main interests are in the area of forest policy and economics, extending from legality verification, international timber trade and forest certification to technology innovation. Other interests include exploring new and innovative ways of communicating science. When he is not researching about the bioeconomy, he procrastinates and draws funny cartoons.

Bioeconomy Art Competition

Other Submissions

Angelie Koerner, University of Applied Science Europe, Germany

Angelie Koerner, University of Applied Science Europe, Germany

Angelie Koerner, University of Applied Science Europe, Germany

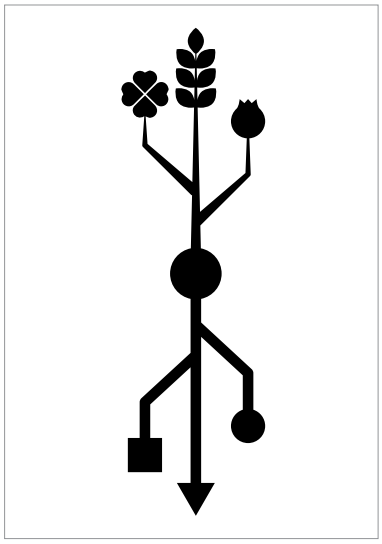
Tanima Banerjee, CSIR-Indian Institute Of Chemical Biology, India

Susrita Samantaray, KIIT School of Biotechnology, India

Rania El-Chichakli, Hildegard-Wegscheider-Gymnasium, Germany

Radhika Rai, Vaibhav Bansal & Utkarsh Parashar: CSIR-National Institute of Science Technology & Development Studies, India

Darya Zaitseva, University of Hohenheim, Germany



Sebastian Björkman, University of Applied Science Europe, Germany

Samadrita Mandal, Deenbandhu Chotu Ram University of Science and Technology, India

Svenja Kölbl, University of Hohenheim, Germany

Jan Maier, University of Hohenheim, Germany

Picture gallery

Opening

Evening Reception

GLOBAL BIOECONOMY SUMMIT 2018

Welcome

Coffee Break

About the German Bioeconomy Council

The Bioeconomy Council advises the Federal Government on the implementation of the “National Research Strategy Bioeconomy 2030” and the “National Policy Strategy on Bioeconomy” with the aim of creating optimum economic and political framework conditions for a biobased economy. The Bioeconomy Council is an independent, voluntary advisory body. Its 17 members cover a broad spectrum of the bioeconomy with their expertise. They identify important fields of action for policy development, search for ways and means towards sustainable solutions and present their findings in a global context. The Council conducts an open dialogue with the general public to stimulate interest in biobased applications and to discuss their contribution to a more sustainable life style. It also provides recommendations on how to support education and training as well as research and development. In this respect, the Council’s activities are aligned with both long-term objectives and current political requirements. Documents download and further information in English is available at www.bioekonomierat.de/english.html

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