Future Opportunities and Developments in the Bioeconomy –
a Global Expert Survey

Bioökonomie*rat*

Foreword

Insights into expectations, drivers and barriers related to sustainable bioeconomy around the world are essential for international policy and collaboration. The findings of this global expert survey indicate that bioeconomy is viewed as central to achieving many of the UN Sustainable Development Goals. Innovations are key in this respect. Besides satisfying food and energy security, bioeconomy is considered central to climate protection and to innovative industrial transformation. Bioeconomy also entails transitioning to sustainable consumption.

In preparation for the Global Bioeconomy Summit 2018 in Berlin, the German Bioeconomy Council decided to commission a survey exploring the key topics of concern to experts around the world.

The Global Bioeconomy Summit has become a forum for discussing and initiating international cooperation in bioeconomy innovation agendas and governance issues. Since organizing the first Summit in 2015, we have observed highly dynamic development in the fields of bioeconomy research, development and policy.

The report provides relevant information for all bioeconomy players. The study has implications for public policy measures and confirms the important role of future international collaboration, especially for research and capacity building in the bioeconomy.

We would like to thank all the experts who have participated in the survey and shared their views, and we acknowledge the contribution made by the authors.

Berlin, April 2018

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Chairs of the Bioeconomy Council

Background

Global insights into future opportunities and developments in the bioeconomy and the needs of specific countries are of prime interest to speed up the evolution required. With this in mind, the German Bioeconomy Council, an independent advisory body to the German Federal Government (see www.biooekonomierat.de/en/), invited experts from all over the world to take part in a Global Expert Survey. The aggregated results will be presented to political leaders; they will help in discussions with representatives of the countries involved, and will feed into the debates at the Global Bioeconomy Summit 2018, which is being held in Berlin (Germany). It will also be possible to see from the outlook where future support and updated policies may be most valuable.

BIOCOM AG in Berlin organized the expert survey on behalf of the German Bioeconomy Council. The participants for this global survey were sampled from 46 countries with established bioeconomy or bioeconomy-related strategies. Officials representing European Union institutions and international organizations were also included. The survey consisted of closed-ended and open-ended, mainly compulsory questions. It was conducted online in the autumn of 2017. The English questionnaire was designed by members of the Bioeconomy Council.

Content

1 Executive summary

Global insights into expected future opportunities and developments in the bioeconomy and the needs of specific countries are of prime interest to speed up the evolution required. With this in mind, the German Bioeconomy Council, an independent advisory body to the German Federal Government, invited experts from all over the world to take part in a Global Expert Survey.

An online survey, which made it possible to address a large number of participants from around the globe and which included several bioeconomy-relevant topics, was designed. Closed-ended and open-ended questions were introduced to obtain the information. All answers collected were analyzed globally and clustered by country. Quantitative and qualitative data analysis was performed.

The experts were asked to elaborate on upcoming success stories and to indicate promising technology fields and notable technology characteristics. Possible solutions to feeding the growing world population were assessed, and potentially conflicting goals were examined. The latter included: non-food use of arable land, use of arable land for feed for meat, milk and egg production, and conversion of virgin forests. Most importantly, the experts were given the option to rate thirty-one policy measures in order of importance to the bioeconomy's market success in the future. Desirable communication and education measures as well as important future investments completed the questionnaire.

The sample included 4,331 experts from 46 countries, representing diverse sectors of operation and including participants with different roles. Officials representing European Union institutions and international organizations were also included. In total, 345 experts (8%) filled in the questionnaire.

Future opportunities and developments in the bioeconomy

The future bioeconomy will satisfy primary human needs; it will be technology-driven and take the environment into account. For the most part, people expect economic advantages. To succeed, policies and strategies will have to pay attention to knowledge transfer and appropriate funding. Depending on the needs of specific countries, however, regional pathways toward the future biobased economy may be most appropriate. So far, blue-sky thinking seems to be mostly absent. Most activities appear to be given over to the day-to-day challenges.

Upcoming bioeconomy success stories

According to the experts, who gave us a total of 832 responses, the future bioeconomy will mainly satisfy human needs in the energy, agriculture and food sector and will provide people with innovative products, all based on renewable materials. Agriculture is fundamental to feeding people, especially in less developed countries. Improvements in agriculture and food ranged from new plant varieties and better production methods to food manufactured from alternative protein sources, e.g. algae or insects. Novel products anticipated included chemicals and bioplastics and new materials, driven mainly by developments in industrialized countries. The energy sector, however, topped all the other success stories (17% of responses). This finding probably reflects the considerable efforts made in recent years, ongoing projects and appreciating the value of bioenergy. It is still notable because bioenergy's reputation has suffered, the commercialization of second generation biofuels has proven to be demanding and political backing for energy based on renewable resources seems to be waning. Surprisingly, the idea of green cities, outlined

as a flagship project candidate in the German Bio-economy Council's 2015 international Delphi study, was mentioned only rarely[1]. However, the reported successes will have a positive effect on major UN Sustainable Development Goals (SDGs).

Promising technology fields
Knowing the promising technologies and their characteristics may help to further streamline existing bioeconomy strategies. When asking participants about technology fields that might enable biobased transformation, we collected a total of 1079 answers. Nearly half of the respondents (42%) proposed an increase in primary sector productivity. Technology fields mentioned included breeding advances, digitalization and the use of alternative biomass sources.

Notable technology characteristics
When asked about characteristics of technologies, which might make sustainable biobased transformation possible we received 1140 responses. The largest group of characteristics relates to economic criteria (37%), which came out well ahead of environmental and technology-oriented characteristics and social factors. Economic criteria included competiveness, innovativeness, circularity and efficiency.

Possible solutions to feeding the world population
One of the outstanding future challenges is to feed the growing world population. The experts, who gave us a total of 1035 reponses, demonstrated great faith in innovation and technological advances to tackle this problem. Using new plant breeds to increase crop yields or using improved production methods were ranked highly across all countries. However, reducing food waste and losses along the supply chain scored even higher and were seen as the most important approach to feeding the growing world population in the future.

Potentially conflicting goals
Different conflicting goals emerged within the context of the growing bioeconomy: non-food uses of arable land, the use of arable land to produce meat, milk and eggs and the conversion of virgin forests.

Box 1: Policy measures assessed

Promoting innovation
Public R&D, private R&D, traditional knowledge and low-tech innovations, public-private partnerships, social innovation

Supporting infrastructure and capacity building
Capacity building, bioeconomy education programs, pilot and demonstration facilities, cluster development

Supporting commercialization
Access to capital, export promotion policy, development and marketing efforts, subsidies for production and use of renewable resources

Supporting the demand-side
Biobased public procurement policy, certification and labels, consumer information and communication campaigns, tax incentives, ban on fossil-based products

Ensuring conditions that encourage the bioeconomy
Removal of fossil fuel subsidies, carbon tax, regulations on biodiversity protection and ecosystem regeneration, circular economy regulations

Promoting good governance
Inter-ministerial and inter-regional cooperation, monitoring and measuring activities, public reporting and multi-stakeholder dialogue, learning and adaptive policy, bioeconomy advisory council

Improving international collaboration in the bioeconomy
Harmonization in international trade & policy frameworks, knowledge-sharing between industrialized and developing countries, private investment in developing countries, international monitoring

More than three quarters of respondents agreed that bioeconomy strategies should deal with these conflicting goals. Suggestions for inclusion in bioeconomy strategies considered the food first principle and, in contrast, holistic approaches. Reducing meat consumption and turning to food and feed alternatives such as insects turned out to be an idea that was heavily advocated in the highly developed countries. Less developed countries regarded yield increases and technological innovations as more helpful. Notably, regulatory approaches turned out to be most popular for preventing the conversion of virgin forests into agricultural land. Ideas included certificates or labels, incentives, taxes or even penalties but the developed countries showed a greater preference for regulatory approaches and policies. They also ranked conservation highly. In contrast, participants from less developed countries preferred land-use optimization, technology innovation and, again, an increase in yields.

Necessary policy measures

From thirty-one suggested policy measures possibly contributing to the market success of the bioeconomy in the future, knowledge and funding are especially necessary (Box 1). According to the 345 experts, know-how should be shared between industrialized and developing countries, professionals should be trained, people educated. Sufficient funding for innovative research and development is required to take the next step. A supportive political framework fostering this would be the final step in enhancing the evolution towards a future biobased economy. The developed countries regarded pilot facilities, the promotion of public research & development, and the removal of fossil fuel subsidies as most important. In contrast, less developed countries viewed knowledge-sharing between in-

dustrialized and developing countries as the most important policy measure overall.

Desirable communication measures

As people do not appear to understand the concept of bioeconomy or how it might improve quality of life without using up the world's natural resources, one solution might be communication campaigns. Respondents clearly preferred passive communication measures, such as campaigns using traditional media channels or social media.

Desirable education measures

The German Bioeconomy Council's 2015 Delphi survey identified education as the key to further development of the bioeconomy, particularly because of the way that natural and engineering sciences and economic and social sciences influence each other. University courses turned out to be most relevant. Vocational training courses were mentioned as a further supporting activity. Interestingly, the respondents would spend more money on education than on communication.

Important future investments

Research drives innovation. Innovation drives product development. Public research money fuels research. When asked about research goals important to future bioeconomy strategies, once again great faith in innovation and technological advance emerges as the strongest driver – irrespective of the country – and proved to be more important than traditional knowledge or social innovations. So, future funds should invest a bigger proportion of money in biotechnology, in high-tech strategies and in increasing yields in traditional farming. Funds to increase yields in traditional farming are especially important for the less developed countries.

2 Methodology

The aim of this survey was to identify trends and to deliver a current snapshot of future opportunities and developments in the bioeconomy.

2.1 Online survey

Future opportunities and developments in the bioeconomy were assessed via an online expert survey in the autumn of 2017.

The aim was to gain insights into the bioeconomy from a global viewpoint, to identify the needs of countries and potential measures that might accelerate the necessary evolution toward a future biobased economy.

With this in mind, online surveys make it possible to address large numbers of participants from around the globe; they reach the target audience quickly and respondents can fill in the questionnaire at their convenience. In addition, the assured confidentiality seems to positively impact response and completion rates.

Table 1: Types of questions	
Topic	**Type**
Upcoming bioeconomy success stories and SDGs	Array of short text boxes
Promising technology fields	Array of short text boxes
Notable technology characteristics	Array of short text boxes
Possible solutions to feeding the world population	Predefined list of possible answers, ranking via drag & drop
Potentially conflicting goals	Combination of yes/no question and text box
Necessary policy measures	Answer categories with a rating scale from 1 (totally unimportant) to 7 (very important)
Desirable communication measures	Numerical input and answer categories with a rating scale from 1 (most important) to 5 (least important)
Desirable education measures	Numerical input and answer categories with a rating scale from 1 (most important) to 5 (least important)
Important future investments	Category list for a paired comparison
Statistical information	List of radio buttons

The majority of questions probed bioeconomy-relevant topics. Statistical information, e.g. the sector of operation, was also collected. Different types of closed-ended and open-ended questions were introduced to obtain the information (Table 1).

Where possible, randomization of answer categories was applied to prevent sequence effects. All relevant questions were compulsory.

The survey was designed and conducted using the open source LimeSurvey online tool. After pre-testing with 14 experts and making improvements to the questionnaire, global experts were sent an e-mail inviting them to take part, which included a personalized link to access the online site.

The questionnaire is included in the Annex.

2.2 Analyses

All answers collected were analyzed: first globally, and second, clustered by country. The latter was especially important for filtering out cluster specificities not visible within the worldwide sample due to the unequal distribution of respondents.

For quantitative analysis, simple descriptive statistics, i.e. frequency distributions, were calculated. The qualitative data analysis was performed using a content analysis approach[2, 3, 4, 5]. It was conducted in two steps. First, the study dataset was analyzed by team members or alternatively using the software tool MAXQDA 11 to produce relevant categories. In addition, categories for technologies and characteristics were derived both by means of lexical analyses of literature and by means of conceptual bioeconomy pathway classifications[6]. The coded data were then tabulated based on word frequency to identify the main categories and according to clusters of countries.

Comments by respondents have been included in this report to emphasize interesting aspects of the survey.

The data collection and analyses for this report were the sole responsibility of BIOCOM AG and the University of Bonn (Questions 10 and 11). More detailed statistical work, such as multivariate analyses, will be the task in upcoming weeks.

3 Sample description

The German Bioeconomy Council defines bioeconomy as the production and utilization of biological resources – including knowledge – to provide products, processes and services in all sectors of trade and industry within the framework of a sustainable economy[7]. The European Commission includes different sectors in its definition, such as agriculture, forestry, fisheries, food and feed, pulp and paper as well as parts of the chemical, biotechnological and energy industries[8]. Several other countries also incorporate parts of the health and pharmaceutical industry.

Bioeconomy strategies have been published by several countries to date. The German Bioeconomy Council published comparisons of these bioeconomy or bioeconomy-related strategies in 2015 (an updated version will be available in 2018), listing comprehensive information on 46 countries worldwide[9,10].

Bearing this in mind, we aimed to build a sample that includes experts from these 46 countries, representing diverse sectors of operation and including participants with different roles, namely members of bioeconomy advisory councils, researchers at public institutions, policy makers, and representatives from companies, associations and civil society organizations. Officials representing European Union institutions and international organizations were also included. Utilizing the BIOCOM in-house database, we selected relevant experts and leaders. Additional participants were identified based on desk research. This search included information mainly from the websites of conferences, national ministries, government agencies, public research institutions, industry associations, companies, and news portals. If there was no specific hit for "bioeconomy" during one of the searches, the search was extended to include keywords like "biobased", "bioenergy", "green chemistry", and "industrial biotechnology". However, in order to identify experts and keep the research within workable limits, additional keywords were only considered in excep-

tional cases. Thus, the bias in the kind and number of respondents, which is caused by the choice of keywords is assumed to be small. To compensate for different national stages of development and the lower visibility of experts in certain countries and to enable us to filter for regional specificities, we subsequently subdivided the 46 countries into five clusters (Box 2). European Union institutions and international organizations (UN, FAO) answers were collected separately.

The model-based clustering was supported by expert consultation and a literature review, which identified a set of globally available, bioeconomy-relevant indicators[11]. These indicators were grouped to reflect the importance of different bioeconomic sectors

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Box 2: Clusters of countries active in bioeconomy[11]

- High-Tech Bioeconomies (HighTech): Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Japan, Netherlands, New Zealand, Norway, Russia, Sweden, United Kingdom, USA
- Emerging Diversified Bioeconomies (EmDiv): Argentina, Brazil, Colombia, (Iceland), Italy, Latvia, Lithuania, Mauritius, Mexico, Paraguay, Portugal, Spain, Thailand, Uruguay
- Diversified Bioeconomies (Diverse): China, Malaysia, Mozambique, South Korea
- Advanced Primary Sector Based Bioeconomies (AdvancedPrim): India, Indonesia, Namibia, South Africa, Sri Lanka
- Basic Primary Sector Based Bioeconomies (BasicPrim): Kenya, Mali, Nigeria, Senegal, Tanzania, Uganda

Note: Only countries with a bioeconomy strategy are listed. Due to data unavailability, Iceland was not included in the original cluster analysis, but was classified as an Emerging Diversified Bioeconomy based on expert consultations.

and the availability of resources. The importance of the primary and high-tech bioeconomic sectors is likely to reflect comparative advantages and to some degree social choice and voter's preferences. The economic importance of the primary sector was based on indicators reflecting the economic significance, employment opportunities and land occupied for a specific sector. Indicators reflecting the economic importance in terms of international trade, patent applications, investments and employment of high skilled personnel were employed to capture the high-tech sector. Comparative advantages, however, are also reflected by the availability of resources, such as bioproductive land and skilled labor. While the availability of bioproductive land is more or less determined by bioclimatic factors, the availability of skilled labor is a result of specific policies.

Background of the participants

In the autumn of 2017, 4,331 experts were invited via email to take part in the global expert survey, with 345 filling in the questionnaire in full (8%).
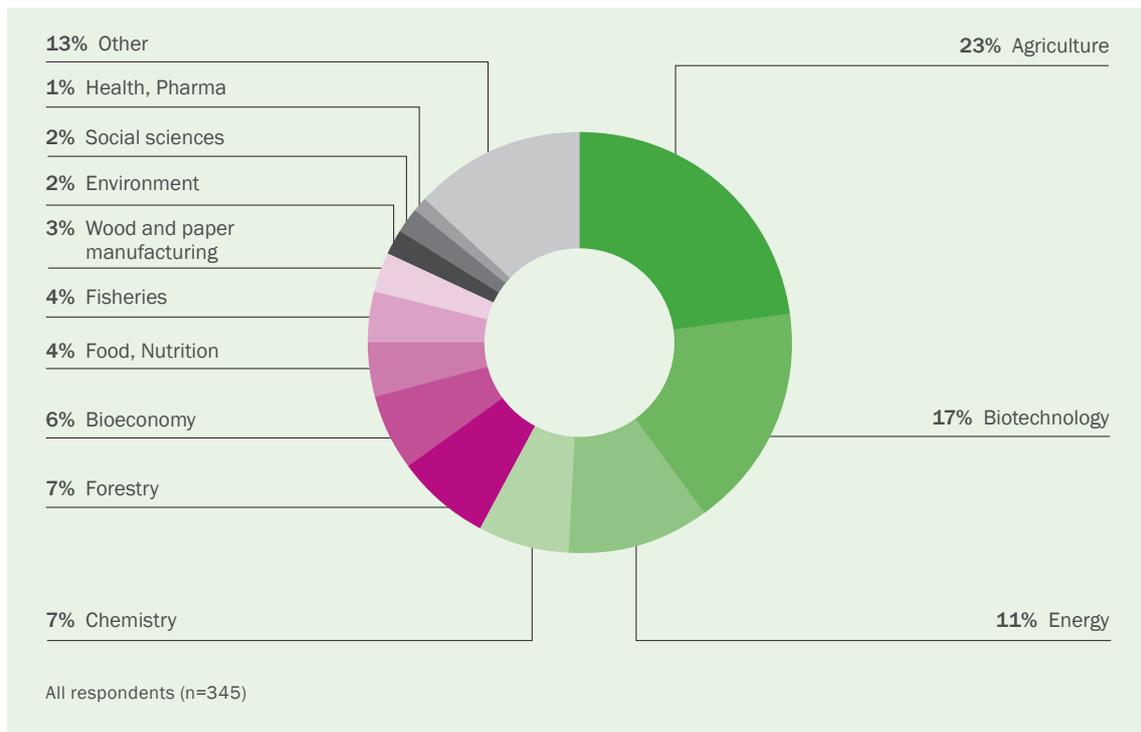
The respondents of the survey cover a wide range of sectors relevant to bioeconomy as described above: agriculture (23%), biotechnology (17%), energy (11%), chemistry (7%), forestry (7%), and

bioeconomy in general (6%) (Figure 1). Additional sectors named included food & nutrition, fisheries, wood & paper, health & pharma. Several respondents are also engaged in environmental settings or social sciences.

Experts in every cluster filled in the questionnaire (Figure 2). Surprisingly, the response rate varied significantly between countries. For example, in the HighTech cluster: Finland (15%), Germany (10%), and France (2%). No answers were received from Mali and Senegal.

Respondents also represented the targeted set of different roles (Figure 3). When asked to describe their role, a majority of 44 percent indicated working as researchers in a public institution. A further 24 percent described their role as policy makers or public administration staff, 20 percent belonged to the industrial sector, 8 percent represented a non-governmental organization (NGO) and 2 percent belonged to an association.

It is worth noting that 28 percent of the experts responding said they were members of a formal, governmental bioeconomy advisory council, adding further weight to the observations of this survey.

13% Other
1% Health, Pharma
2% Social sciences
2% Environment
3% Wood and paper manufacturing
4% Fisheries
4% Food, Nutrition
6% Bioeconomy
7% Forestry
7% Chemistry
23% Agriculture
17% Biotechnology
11% Energy

All respondents (n=345)

Figure 1: Respondents cover important sectors of operation

5% European Union Institutions

6% Basic Primary Sector Based Bioeconomies

8% Advanced Primary Sector Based Bioeconomies

2% Diversified Bioeconomies

29% Emerging Diversified Bioeconomies

4% International Organizations

46% High-Tech Bioeconomies

All respondents (n=345)
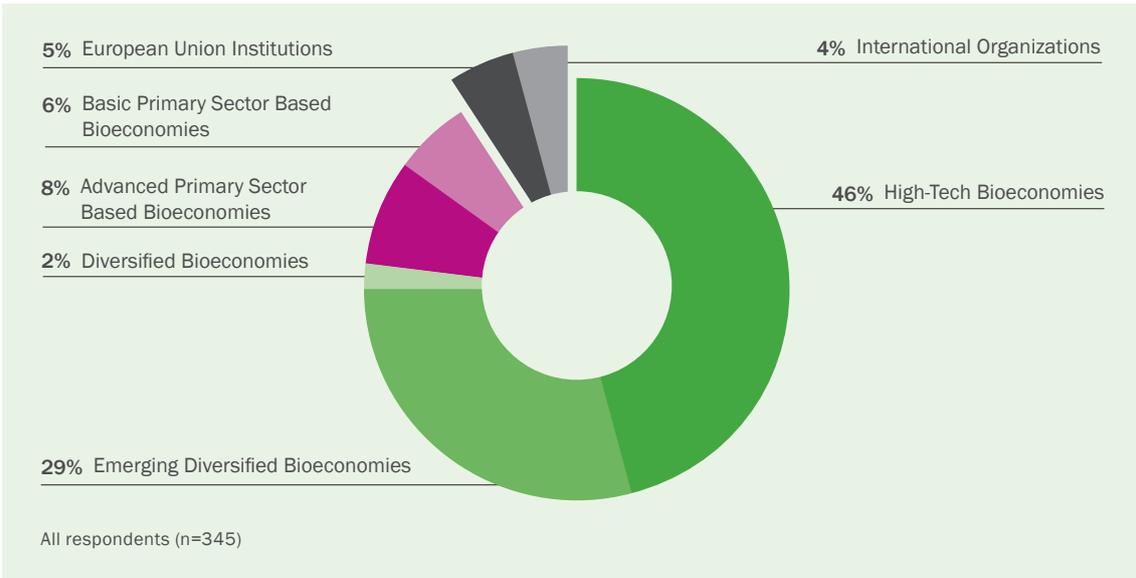
Figure 2: Respondents represent every cluster, European Union Institutions, and International Organizations

2% Association

8% Civil society organization / Non-governmental organization

20% Industry

24% Policy maker/ Public official / Public administration
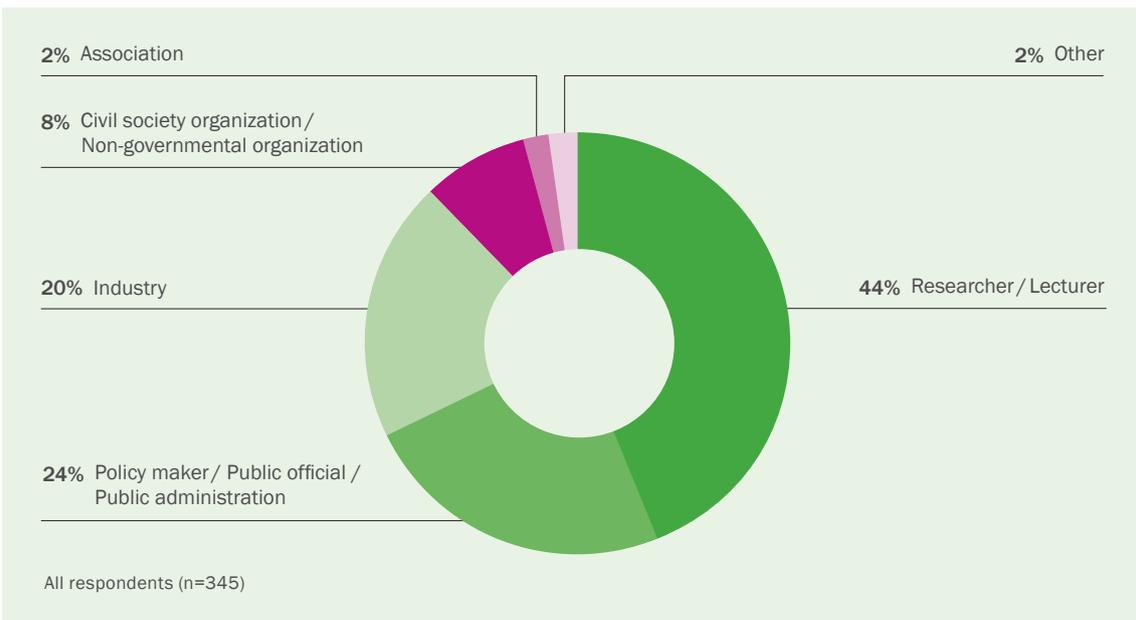
2% Other

44% Researcher/ Lecturer

All respondents (n=345)

Figure 3: Respondents active in relevant roles

4 Survey results

4.1 Upcoming bioeconomy success stories

Energy, biobased products and agriculture, food & feed top future successes
Asking worldwide respondents about promising bioeconomy success stories in their country over the next 20 years led to a diverse set of answers (Figure 4). Irrespective of ongoing discussions, the energy sector and, in particular, different energy routes ranging from bioenergy in general to biogas and biofuels showed up as the most prominent future success story (n=141). This finding probably reflects the considerable efforts made in recent years, ongoing projects and appreciating the value of bioenergy. It is still notable because bioenergy's reputation has suffered, the commercialization of second generation biofuels has proven to be demanding and political backing for energy based on renewable resources seems to be waning.

Other respondents anticipated novel, innovative products as future pioneers of the bioeconomy. (n=125). In focus: chemicals and bioplastics and innovative new materials, e.g. wood fibers for clothing obtained from waste or residues.

Improvements in agriculture ranging from new plant varieties to smart features like automated workflows and better production methods took third place (n=61). Successes in the food and feed area, e.g. food manufactured from alternative protein sources or sustainable food systems, came next (n=44).

Green cities mentioned rarely
The valorization and reduction of waste (n=42), e.g. "to combine urban organic waste management with value creation and not just energy production", as well as improvements in technology and process development (n=42) were also mentioned frequently. Education with respect to bioeconomy was also named as a future success story several times (n=29). Surprisingly, the idea of green cities, outlined as a flagship project candidate in the German Bioeconomy Council's 2015 international Delphi study was mentioned only rarely (n=12).

Other answers included aspects such as gender equality, job creation, economic growth and diversification or improved innovation.

Clusters' successes differ
Clusters varied in their answers: HighTech countries envisage notable success stories especially in the product and energy sector. Energy, products and agriculture receive top marks from the EmDivs. Advanced technology and development activities in these countries may explain a strong product pipeline in the HighTech and EmDivs.

Participants in AdvancedPrim and BasicPrim countries favor other scenarios. AdvancedPrims also give top ranking to energy but agriculture, education and health follow. For BasicPrims, success stories will mainly be delivered within agriculture. Education, energy and less hunger are ranked next. The importance of agriculture comes as no surprise since these countries are still struggling to feed the ever-growing population.

Sustainable Development Goals affected strongly
Asked about the UN Sustainable Development Goals (SDGs) that will be affected by promising bioeconomy success stories, respondents included every SDG to a certain extent (Figure 5). Nevertheless, three SDGs stood out within the global sample: responsible consumption and production (SDG 12), industry, innovation and infrastructure (SDG 9) and climate action (SDG 13). Affordable and clean energy (SDG 7), good health and well-being (SDG 3), sustainable cities and communities (SDG 11), and decent work and economic growth (SDG 8) followed next. Peace, justice and strong

institutions (SDG 16), gender equality (SDG 5) and reduced inequalities (SDG 10) turned out to be the SDGs least affected.

Looking into the clusters, the three SDGs selected most often in the global sample are important to every country. However, BasicPrims and AdvancedPrims also placed high emphasis on reducing poverty (SDG 1) and hunger (SDG 2) and increasing good health and well-being (SDG 3). The more developed EmDivs considered decent work and economic growth (SDG 8) the SDG more affected.
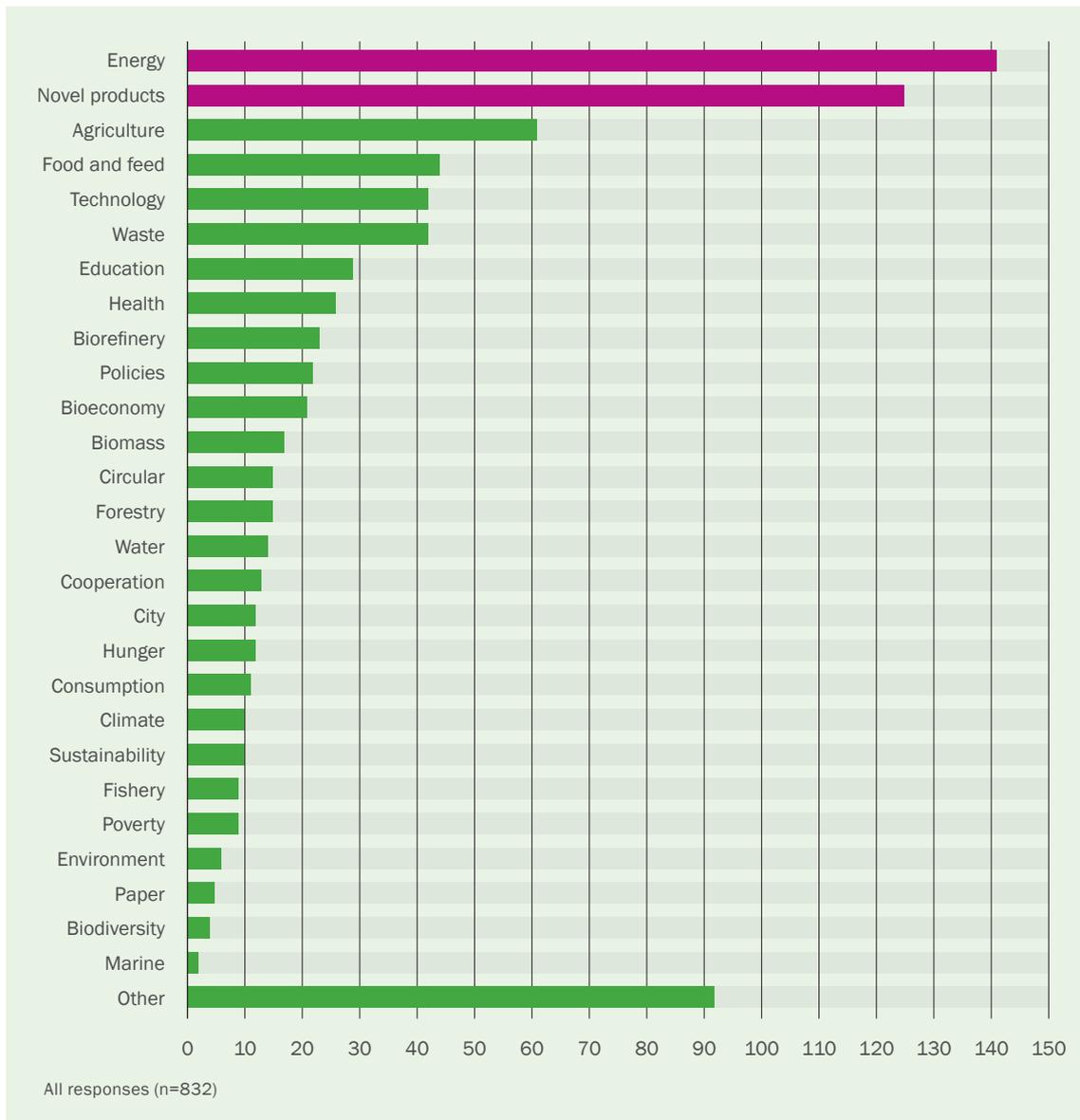
Figure 4: Upcoming bioeconomy success stories
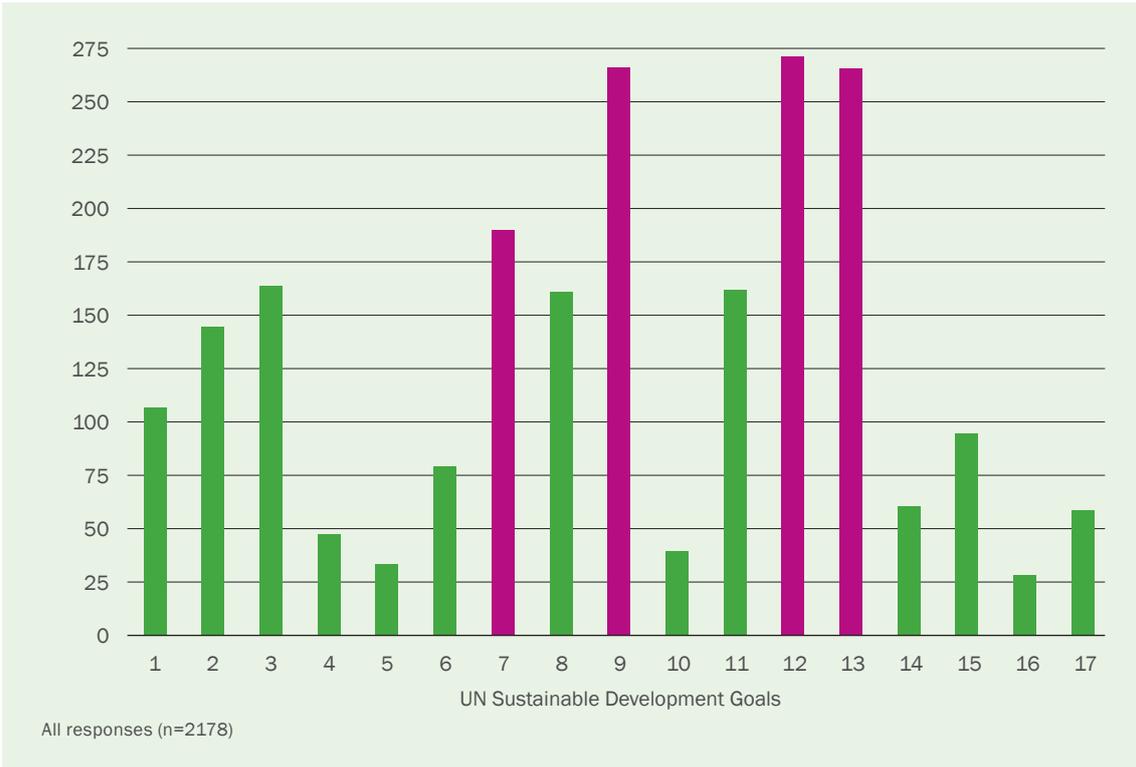
Figure 5: UN Sustainable Development Goals affected

4.2 Promising technology fields

Technologies drive transformation in the bioeconomy. Asking participants about promising technology fields that might enable this process, the most frequently collected answers proposed an increase in primary sector productivity (n=452) (Figure 6). Technology fields included breeding advances, applying classical breeding or modern molecular biological technologies, such as CRISPR/Cas9, digitalization ranging from the use of information and communication technologies to artificial intel-

Figure 6: Promising technology fields

ligence and big data analyses as well as the use of alternative biomass sources. Precision farming was another topic. Within the green cities context, urban farming was only mentioned by a small fraction of respondents, which might also be caused by the procedure in the selection of survey participants. The second most common responses considered the addition of biobased value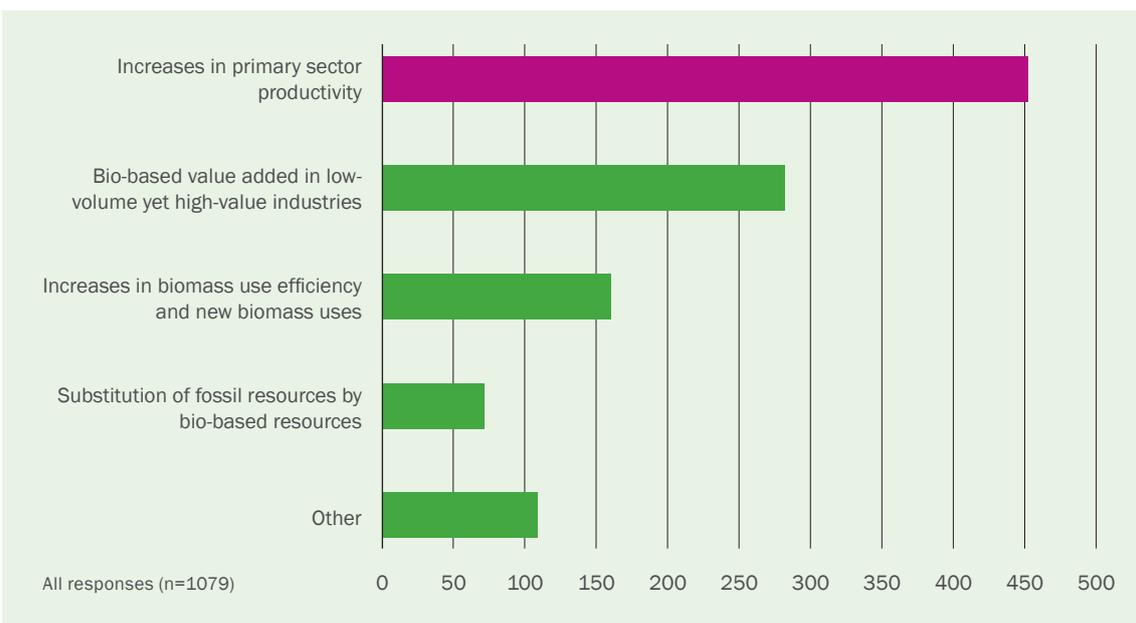 in low-volume yet high-value industries (n=283), e.g. by applying metabolic engineering or enzyme technologies. Increases in the efficiency of biomass use and new biomass uses (n=160) could be made available as a result of new processing technologies.

Clusters showed no major differences – they most often referred to technology fields in terms of increasing primary sector productivity. One explanation might be that biomass is the prerequisite for the future biobased economy.

4.3 Notable technology characteristics

The content analysis highlighted several characteristics of technologies, which might make sustainable biobased transformation possible. The largest group concerns economic criteria (n=420), well ahead of environmental and technology oriented characteristics in second (n=238) and third place (n=188) respectively and social factors (n=155) (Figure 7). Economic criteria include competitiveness, innovativeness, circularity and efficiency. Environmental sustainability and resource efficiency relate to the environment. Yield optimization is by far the most prominent criterion for technology goals.

Every cluster mentioned economic criteria most frequently. Differences were observed in the other characteristics. Social factors were collected more frequently than technology goals from the less developed countries, such as BasicPrims and AdvancedPrims. In contrast, a smaller proportion of HighTech countries reported social factors.

4.4 Possible approaches to feeding the world population

Reduce food waste to feed the population
Global experts, except for the BasicPrim participants, rated the reduction of food waste and losses along the supply chain as the most important ap-

proach to solving the challenging global question of how to feed the growing world population in the future (Figure 8). An FAO study suggested that roughly one third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year[12]. The food is lost or wasted throughout the supply chain, from initial agricultural production down to final household consumption in both developed and less developed countries. The causes of food losses and waste in low-income countries are mainly connected with financial, managerial and technical limitations. Food waste in industrialized countries can be reduced by raising awareness among food industries, retailers and consumers. Respondents from EU and international organizations like the UN and FAO also shared the view that the most appropriate solution to feeding the growing world population is to reduce food waste and losses.

Countries believe in innovation
Increasing crop yields using innovations like new plant breeds and seeds or using improved production methods take second and third place respectively, reflecting great faith in innovation and technology. Increasing the land available for crops by converting grassland and/or wilderness is seen as the least suitable solution. Interestingly, reducing meat consumption in industrialized countries or reducing and optimizing the use of water for agriculture were ranked equal in the midfield.

New plant breeds and seeds and improved production methods to increase crop yields are similarly favored by respondents from different clusters. BasicPrim countries in particular view improved production methods as very important. This is most probably because more developed countries already show satisfactory agricultural output levels. Nevertheless, this solution also receives high marks in the developed countries.

Reduce meat consumption
Global meat consumption is still rising despite discussion about reducing it. One explanation is the increasing wealth of several fast-developing countries, e.g. China. According to this survey, reducing meat consumption in industrialized countries is an idea, which is favored by experts from HighTech countries and European institutions. Both voted
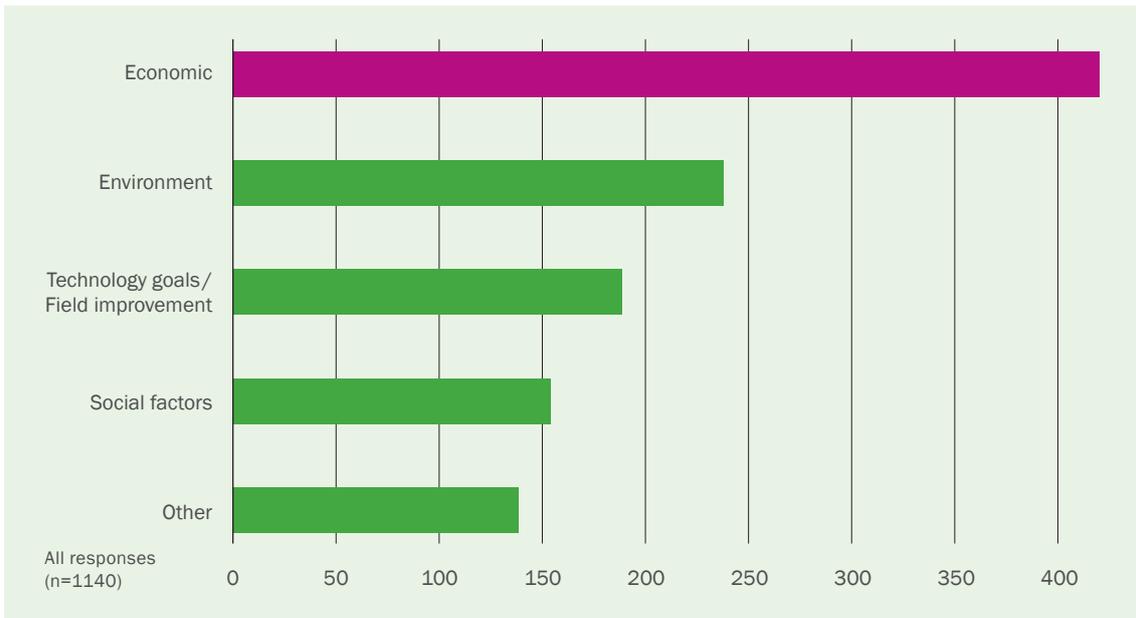
Figure 7: Notable technology characteristics

strongly in favor here. The idea of developing new sources of food production, such as algae or insects, seems to be preferred. In contrast to High-Tech countries, several less developed countries serve insects as traditional food. This might explain why respondents from HighTech countries rated this solution as more important. Increasing the nutritional value of products is a priority for the less developed countries. Water is a valuable commodity, especially in several of the AdvancedPrim and BasicPrim countries. Not surprisingly, reducing and optimizing the use of water is viewed as another possible solution. Interestingly, international organizations viewed this solution as very important. Using edible biomass primarily for food, producing food in towns and cities, e.g. by roof and vertical farming, or increasing the land available for crops by converting grassland are less favored solutions to feeding the growing population – irrespective of the country.

Access as an alternative solution

Some respondents also pointed to additional solutions. Access was one example. Access to land, education and food. The latter by "benefit sharing", for example. Combining approaches may be another logical way of moving forward. For example, using improved cultivation methods in combination with improved water management to increase crop yields. Further ideas suggested "bringing back

forgotten crops like millet and sorghum that are more resistant to drought and thus more resilient to climate change", "natural resources" and the use of "marginal or waste land".

4.5 Potentially conflicting goals

In the context of the growing bioeconomy, different conflicting goals have evolved in recent years. The non-food use of arable land, life cycle assessments and rising crop prices have triggered food and fuel discussions. Using arable land to produce feed for meat, milk and eggs raised the question as to whether this concept will continue in the future. Finally, the conversion of virgin forests threatens global biodiversity. Survey respondents assessed these conflicting goals and provided suggestions for resolving them.

4.5.1 Non-food use of arable land

More than three quarters (77%) of the respondents think that bioeconomy strategies should deal with the fact that about 10-15% of the worldwide arable land (1.5 bn hectares) is not used for food production but for bioenergy crops or crops for bioindustrial use. In particular, suggestions considered holistic approaches and in contrast, the food first principle as well as improved land and waste use (Figure 9).

Holistic approach contrasts with food first principle

Several participants (n=35) say bioeconomy strategies should be focused on simultaneous production of food and bioenergy or other biobased products, the holistic approach. It is mentioned that "cereals like sugarcane, corn, sorghum, rice and wheat are cropped worldwide. And all of them have the potential to produce not only food but bioenergy". On the other hand, several respondents underlined the food first principle (n=28).

Splitting the answers according to clusters, holistic and "food first" approaches seem to be favored equally by the different countries.

Land use management important

Land use is also important for respondents (n=30). It should be promoted by government policies, carefully monitored and optimized. Marginal land in particular should be better exploited e.g. by uti-

lizing new crop varieties. One comment pointed out that a "significant portion of arable land has always been used for non-food materials and energy and should be treated as an integral part of land use practices". Optimization of land use is suggested primarily by the HighTech and EmDiv countries.

Further increases in yields or the use of alternative resources, e.g. from marine or forest habitats, could also be part of a future solution. Cascading use and multiple purpose crops are discussed. Respondents also highlighted regional aspects and the necessity of taking local needs and conditions into account. Suggestions included using alternative renewable energy sources, such as solar or wind power, instead of bioenergy originating from arable land. HighTech, EmDivs and BasicPrims indicated waste valorization and reduction in particular as possible measures.
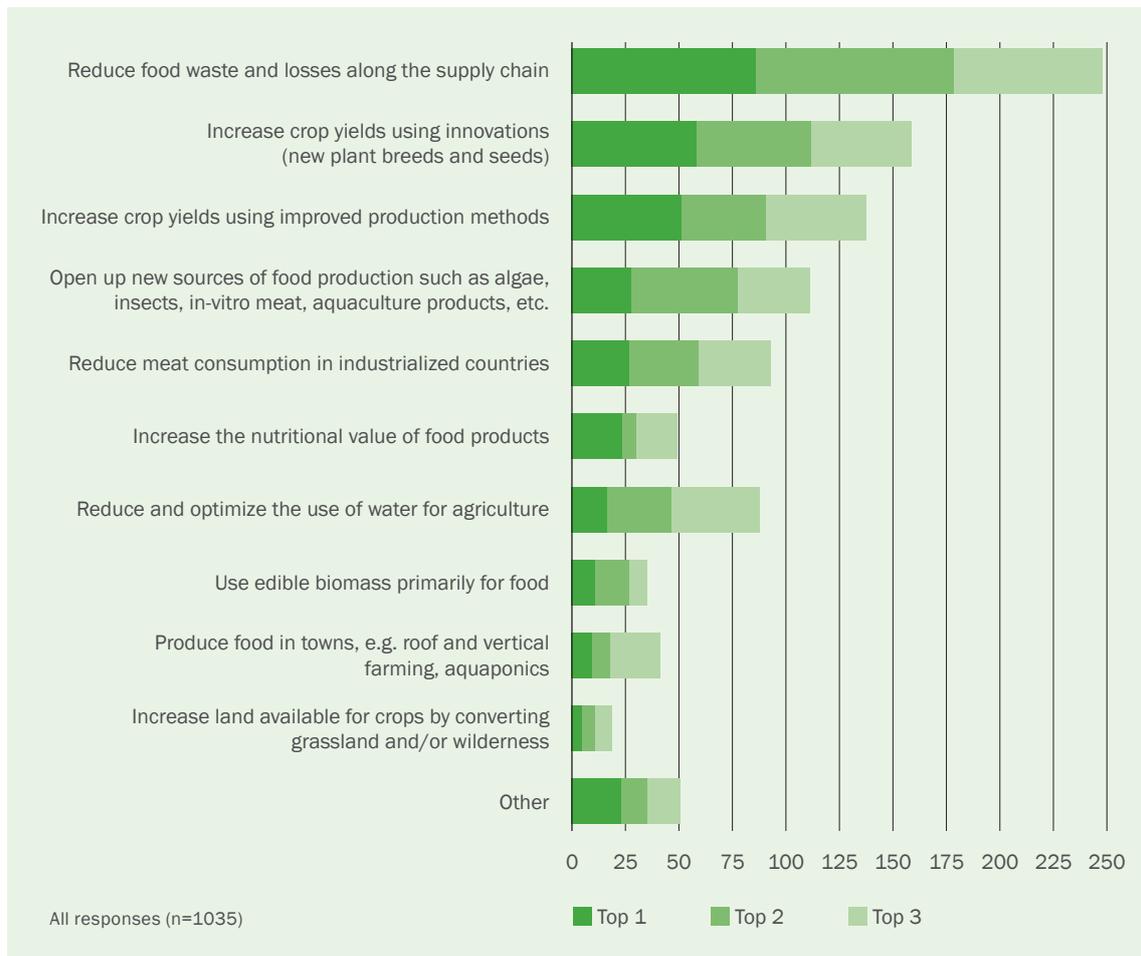
Figure 8: Three most important approaches to feeding the growing world population in the future

4.5.2 Use of arable land for feed for meat, milk and egg production

About one third of the global crop land is used to produce feed for meat, milk and egg production, mainly in industrialized and emerging countries. There is criticism that world market prices for plant-based food increase as a result and make the situation worse for the poor. More than three quarters of respondents (77%) agreed that bioeconomy strategies should deal with this challenge.

Three main approaches

The suggestions highlight three main approaches (Figure 10). First, as discussed earlier on, reducing meat consumption and feed usage (n=34). Second, opening up avenues for protein and carbohydrate alternatives, such as insects, algae or yeast, for human consumption and feed use (n=29). "Protein sources could be produced by microorganisms instead of animals. Single cell proteins are produced by microorganisms faster, cheaper and from poor raw materials by comparison with animal proteins. Less animal protein means more grains available in the world market. More grains in the market means

lower prices or more stable prices worldwide". The third suggestion considered, once again, increasing the yields and efficiency of existing agricultural production systems (n=29).

When scrutinizing the cluster-specific responses, it again appears that reducing meat consumption is an idea widely propagated in the HighTech countries and to a lesser extent in the EmDiv countries. The same holds true for food and feed alternatives, such as insects or algae. In contrast, less developed countries regarded yield increases and technological innovations as more helpful. One participant stated that "most of the poor live in the developing world where large tracts of land are still uncultivated. The focus should therefore be to make technologies available, e.g. mechanization and improved hybrids, to enable the poor to produce sufficient food for their households".

In the midfield of the suggestions are the use of new technologies (n=15) and pursuing a holistic approach (n=13). In general, regional specificities should be taken into account (n=12).
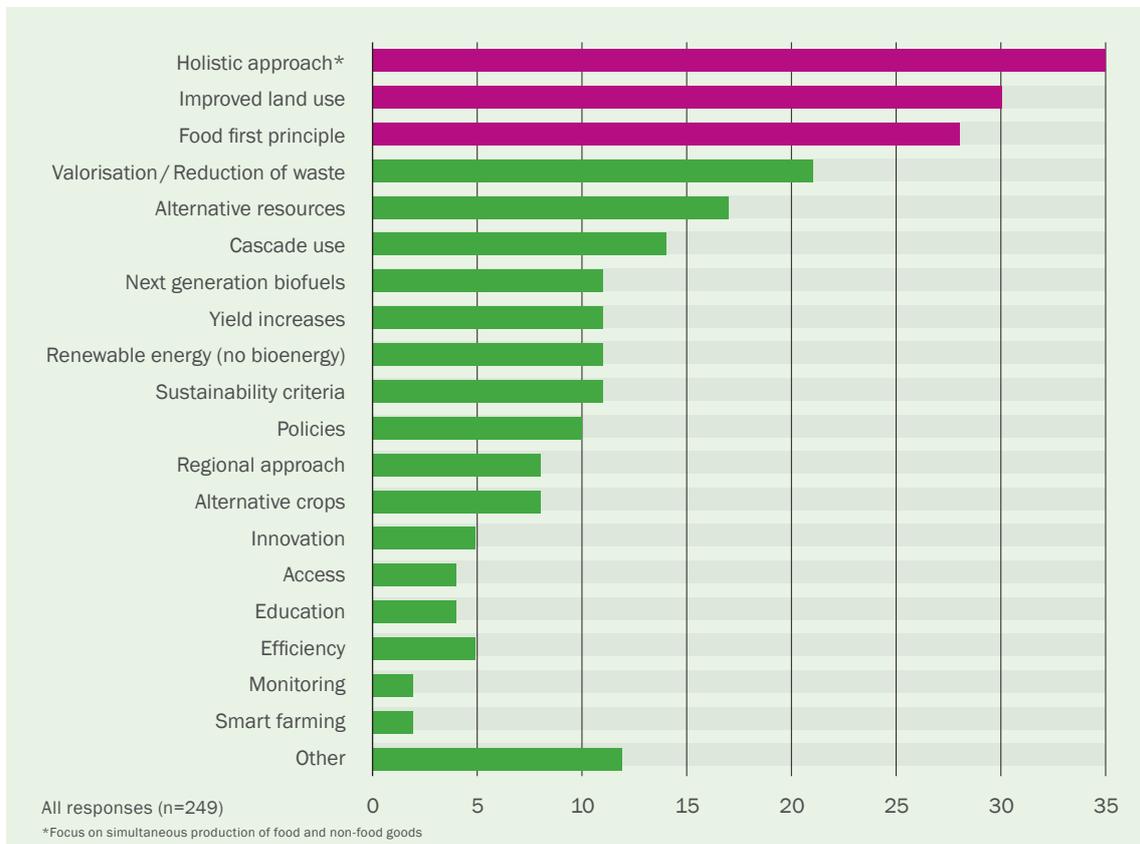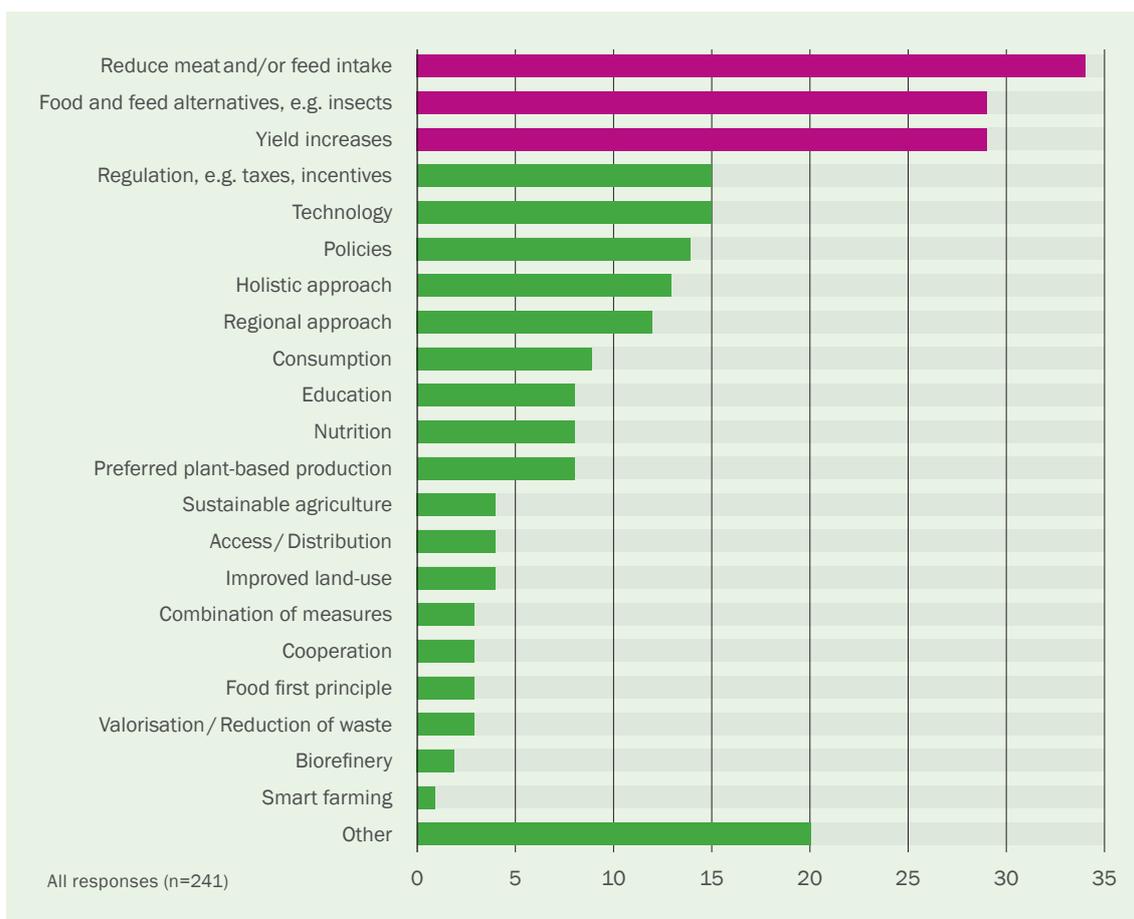

Figure 9: Non-food use of arable land – suggestions to resolve conflicting goals

Figure 10: Use of arable land for feed for meat, milk and egg production – suggestions to resolve conflicting goals

Other suggestions concerned policies and regulatory measures, primarily considered by HighTechs, EmDivs and AdvancedPrims, such as taxes, e.g. "a meat tax, differentiated according to the climate and environmental consequences of different kinds of meat" or incentives, e.g. "so that farmers produce for human consumption". An explanation for this might be belief in the political system in these countries and its regulatory power.

4.5.3 Conversion of virgin forests
There is criticism that virgin forests, in South East Asia and Latin America for example, are converted into agricultural land to produce palm oil, soybeans or beef for export. Nine out of ten respondents (86%) share the opinion that bioeconomy strategies should deal with this fact.

Regulatory approaches most popular
Two main suggestions are prioritized (Figure 11). Surprisingly, regulatory approaches ranked as most popular (n=51). Ideas include certificates or labels,

incentives, taxes or even penalties. One participant noted that "access to foreign, better value markets should be restricted by tariffs and taxes". Others opted for bans and embargoes on palm oil, soybeans, etc.

The developed countries in particular view regulatory approaches and policies as the top measure for dealing with the conversion of virgin forests.

Yield increases and conservation to save forests
As mentioned before, increasing yields and productivity as well as optimizing land use are important to the respondents. They also appear relevant for preventing virgin forests from being converted into agricultural land. An obvious measure for 35 respondents is the strict conservation of virgin forests.

Looking into the clusters, it becomes obvious that the more developed the countries, notably here the HighTechs and EmDivs, the higher is the priority for conserving virgin forests. Once again, this observa-

tion might be explained by the different needs of the countries responding. The least developed countries still struggle to feed their people, so the protection of forests ranks lower. Participants from BasicPrims and AdvancedPrims prefer land-use optimization, technology innovation and an increase in yields.

Other suggestions included sustainability aspects (n=24), international or national policies (n=23), specific regionally oriented measures (n=11); analyses to evaluate the ecosystem services of the virgin forests or to calculate costs and benefits were also indicated. There was less mention of changing consumption habits or applying new technologies but "food should be considered a local issue and not be targeted at satisfying the immense demand of developed economies".

4.6 Necessary policy measures

It is possible to imagine a diverse set of policy measures aimed at promoting the bioeconomy's market success in the future. During this survey the participants rated thirty-one measures in total, subdivided into seven groups. In general, the developed countries rated their respective needs

lower than the less developed countries. Interestingly, the international and the EU group adopted different positions on several occasions.

Promoting innovation
Respondents rated public research and development money (57%), private money (47%) and public-private partnerships (PPPs, 55%) as most important for driving innovation worldwide (Figure 12).

Public and private funding received top ratings within the HighTech cluster. PPPs were especially important for less developed countries like AdvancedPrims and BasicPrims and also for respondents working within international organizations. Overall, social innovation, e.g. open innovation or citizen science, and traditional knowledge and low-tech innovations are viewed as less important innovation measures. Nevertheless, both measures are important for the less developed countries.

Supporting infrastructure and capacity building
Looking from the global perspective at the support necessary for infrastructure and capacity building, pilot facilities (57%) take the lead followed by bio-
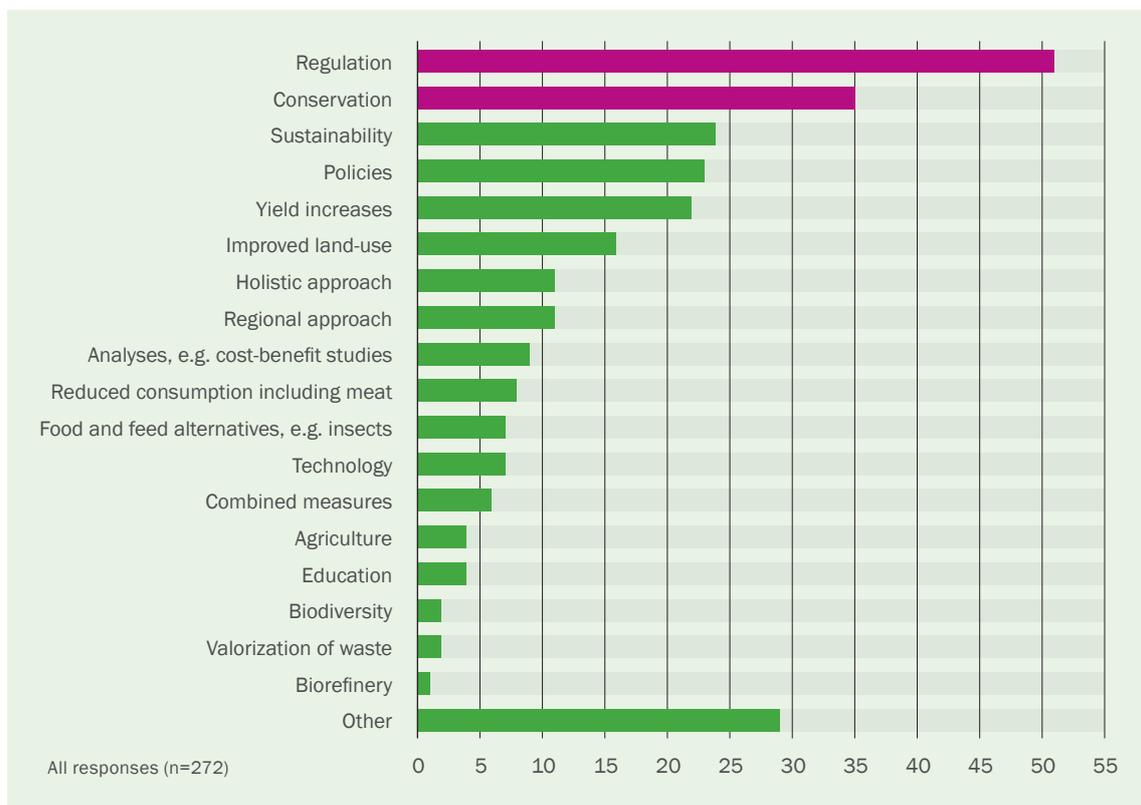
Figure 11: Conversion of virgin forests – suggestions to resolve conflicting goals
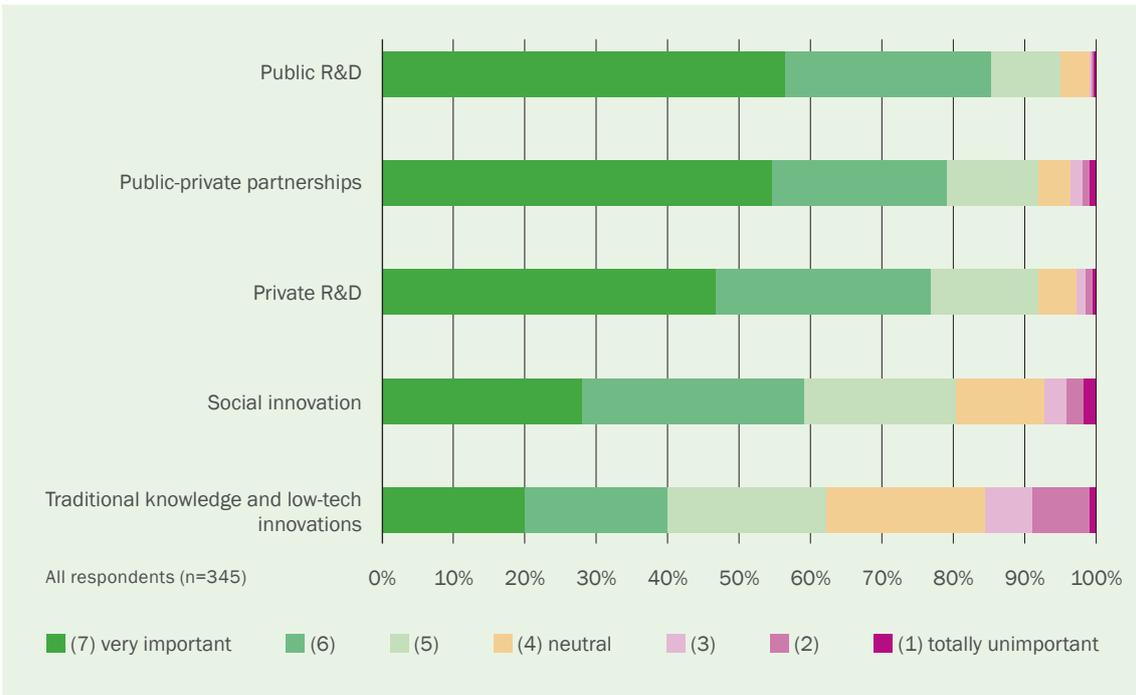
Figure 12: Policy measures aimed at promoting innovation

economy education programs (44%) and capacity building (44%) (Figure 13). Cluster development seems less important.

In comparison, pilot facilities are most sought after by the HighTech countries. This is most probably because product developments have already reached advanced stages. On the other hand, education is a big issue in

emerging and developing countries. AdvancedPrims and BasicPrims in particular rated capacity building as equal to the need for pilot facilities. In comparison, a substantially smaller proportion of HighTech respondents rated this measure as most important.

Supporting commercialization
According to 50 percent of all respondents, access to
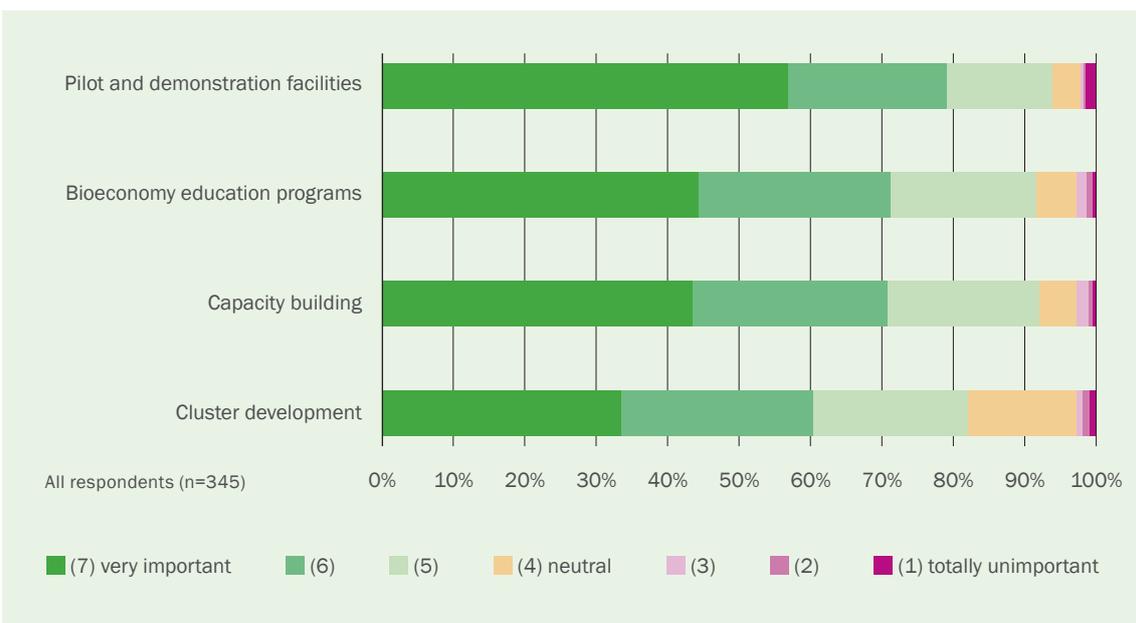
Figure 13: Policy measures aimed at supporting infrastructure and capacity building
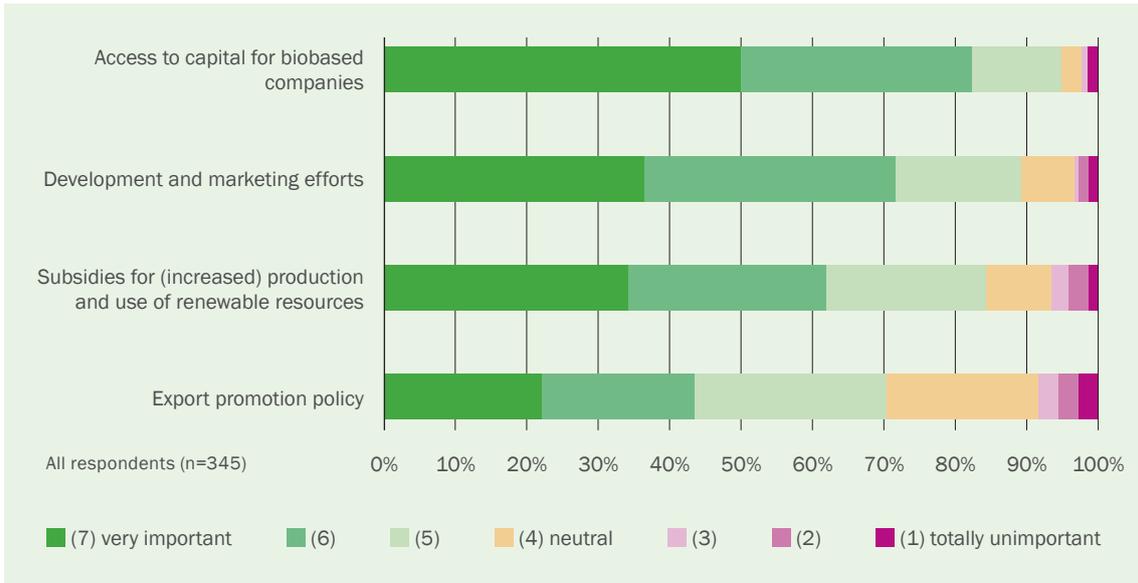
Figure 14: Policy measures aimed at supporting commercialization

capital for biobased companies is the most important commercialization support measure for promoting the bioeconomy's market success in their home country. Development and marketing efforts take second place (37%). Only 22 percent of the responses indicated export promotion policies as most important (Figure 14).

Only BasicPrims rated the latter measure more positive than subsidies for the production and use of renewable resources. Strained national budgets might explain this observation. Interestingly, EU officials ranked export promotion policies as less important than respondents from international organizations. This may be because of the existing large European single market.

Supporting the demand-side
According to the global panel, three proposed measures for supporting the demand-side appear
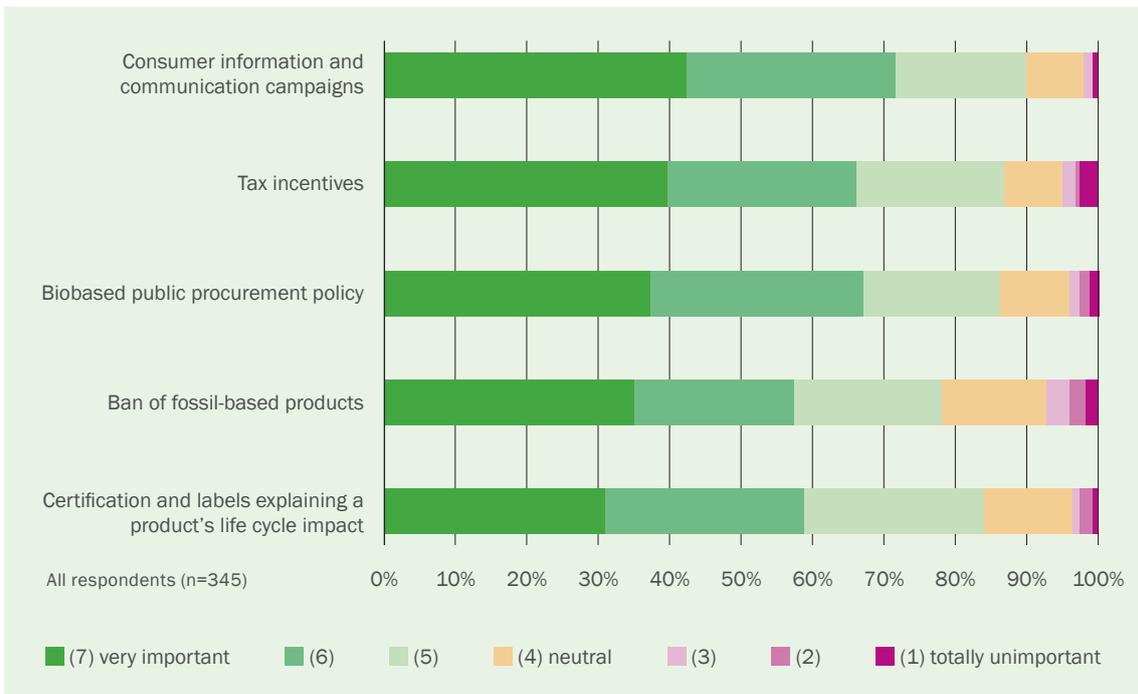
Figure 15: Policy measures aimed at supporting the demand-side
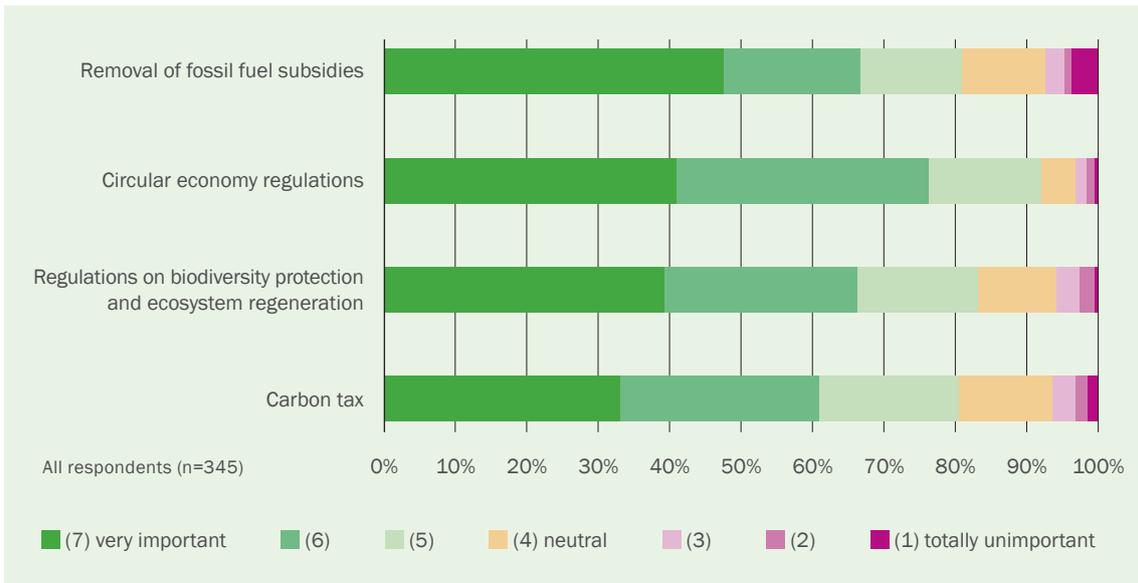
Figure 16: Policy measures aimed at ensuring conditions that encourage the bioeconomy

to be most popular: consumer information and communication campaigns (43%), tax incentives (40%), and biobased procurement policies (38%) (Figure 15).

International organizations rated tax incentives very highly. With regard to public procurement, BasicPrims and AdvancedPrims, notably show up as the countries with the smallest needs. Unlike the developed countries, they do not consider public procurement policies for promoting biobased markets as very important. Weak public procurement within these countries might be an explanation for this observation. The ban on fossil-based products, such as plastic bags, receives only a low rating from EU respondents. This is probably because the EU already moved to reduce plastic bag use by a directive introduced in 2015[13].
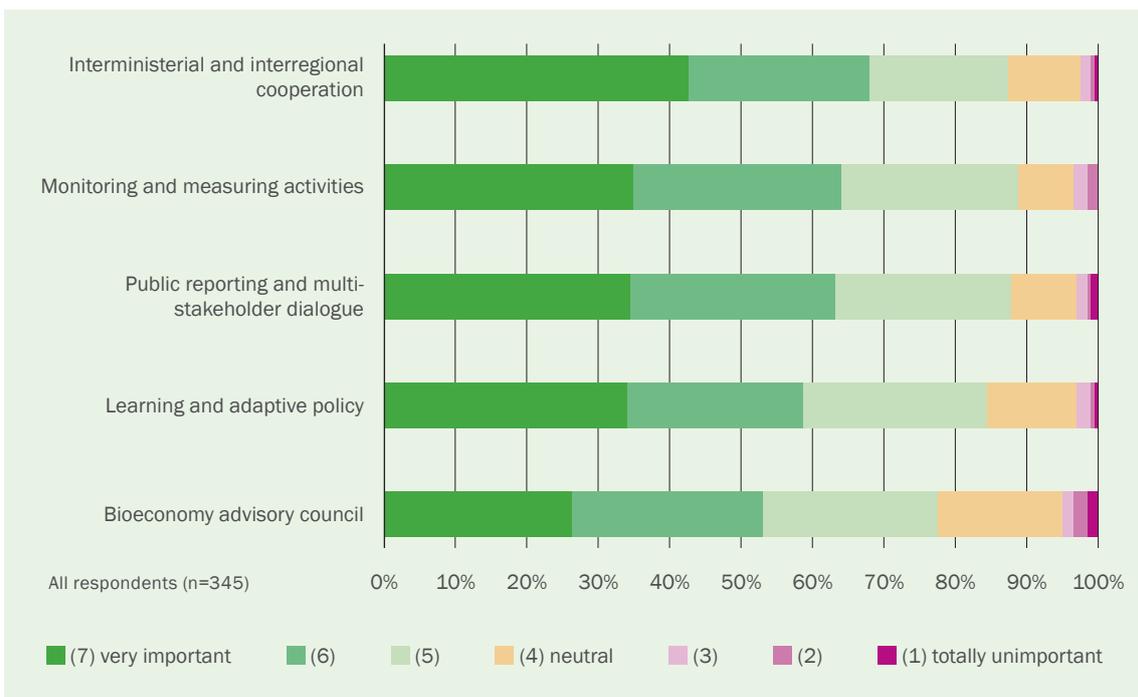
Figure 17: Policy measures aimed at promoting good governance
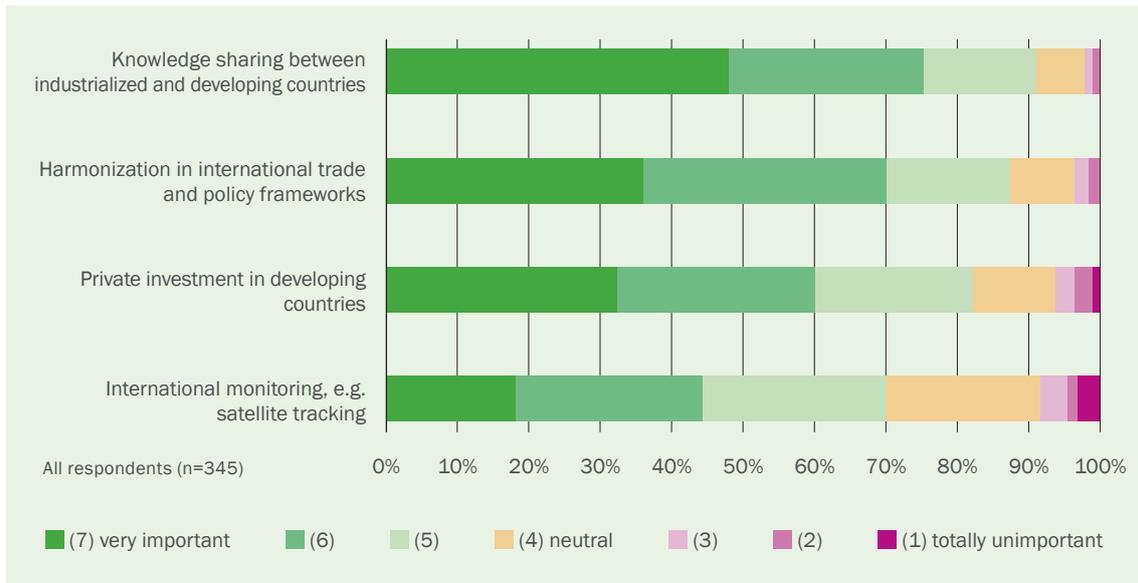
Figure 18: Policy measures aimed at improving international collaboration in the bioeconomy

Ensuring conditions that encourage the bioeconomy
Looking from a global perspective at conditions encouraging the bioeconomy, the removal of fossil fuel subsidies takes one of the top positions (48%) (Figure 16). One explanation might be the HighTech countries' great interest in their removal. This observation might also hint at the lack of subsidies in the less developed countries or perhaps that less developed countries seek to draw closer to developed countries and therefore rely heavily on fossil fuels. Irrespective of the country cluster, respondents think that circular economy regulations, such as recycling quotas, use of by-products, eco-design, life cycle assessment of patents, are very important (41%).

Interestingly, the carbon tax is sought almost equally by the different clusters.

Promoting good governance
According to the global panel, cooperation between ministries or regions is rated as most important (43%) (Figure 17). An expert bioeconomy advisory panel is viewed as least important (26%).

In contrast to international actors, respondents from EU institutions view cooperation between ministries or regions as highly important. One reason might be the multitude of countries and regions under the European umbrella, which necessitates good bonding to succeed. However, public reporting and multi-stakeholder dialogues appear well established in Europe. Reporting and monitoring measures receive high ratings from the less developed countries.

Improving international collaboration in the bioeconomy
Knowledge sharing takes the top position (48%) for improving international collaboration in the bioeconomy (Figure 18). Harmonization of frameworks (36%) and private investment in developing countries (32%) rank next.

For BasicPrim countries, knowledge sharing between industrialized and developing countries turns out to be the most important measure for the future of the respective bioeconomy's market success. One explanation might be the weak presence of innovative knowledge in these countries and their desire to close this gap as quickly as possible. Harmonization in international trade and policy frameworks is especially important for the HighTech countries. When asked about international monitoring, such as satellite tracking, this proposed measure is viewed as the least interesting for all countries (18%). One reason might be high costs, necessary knowledge and an uncertain outcome.

In conclusion, a set of important policy measures has been identified for promoting the bioeconomy's market success in the future. However, when asking actors from different countries, differences do exist. In general, the more developed the national

economies are, the less important individual measures. One explanation might be the different levels of existing economic, technological, scientific and political prerequisites.

Knowledge and funding are especially necessary for advancing national bioeconomies. The know-how should be shared between industrialized and developing countries, professionals should be trained, people educated. Sufficient funding for innovative research and development is required if the next step is to be taken. A supportive political framework would be the final step towards enhancing the evolution towards a future biobased economy.

4.7 Desirable communication measures

Attempts to communicate the concept of bioeconomy or how it could improve quality of life without using up the world's natural resources could be key to its further development. According to this global survey, respondents would use 10 to 20 percent of the total government funding for bioeconomy for public communication and/or citizen engagement, depending on the country. The more developed the cluster is, the lower the amount spent: HighTechs (10%), BasicPrims (20%).

Passive communication preferred

However, passive communication measures, such as campaigns using traditional media channels (35%) or social media (32%), are preferred (Figure 19). Active dialogues with citizens (23%) and non-governmental organizations (21%) take a middle position. Exhibitions (12%) seem less important as communication tools maybe because of their smaller outreach and the greater effort required.

A closer look reveals interesting preferences between the different clusters. International respondents clearly viewed traditional media as most important. In contrast, European officials viewed communication campaigns using traditional or social media as less important. One reason might be firmly established communication channels within Europe. Instead, they preferred dialogues with citizens. Interestingly, this is not a view reflected by the HighTech cluster.

It is worth noting that communication campaigns via social media are viewed as least important by the BasicPrim cluster. This observation might reflect the status of Internet accessibility within these countries. Comparing the clusters with regard to dialogues with citizens and NGOs, the picture is mixed. This observation might reflect regional aspects or attitudes.
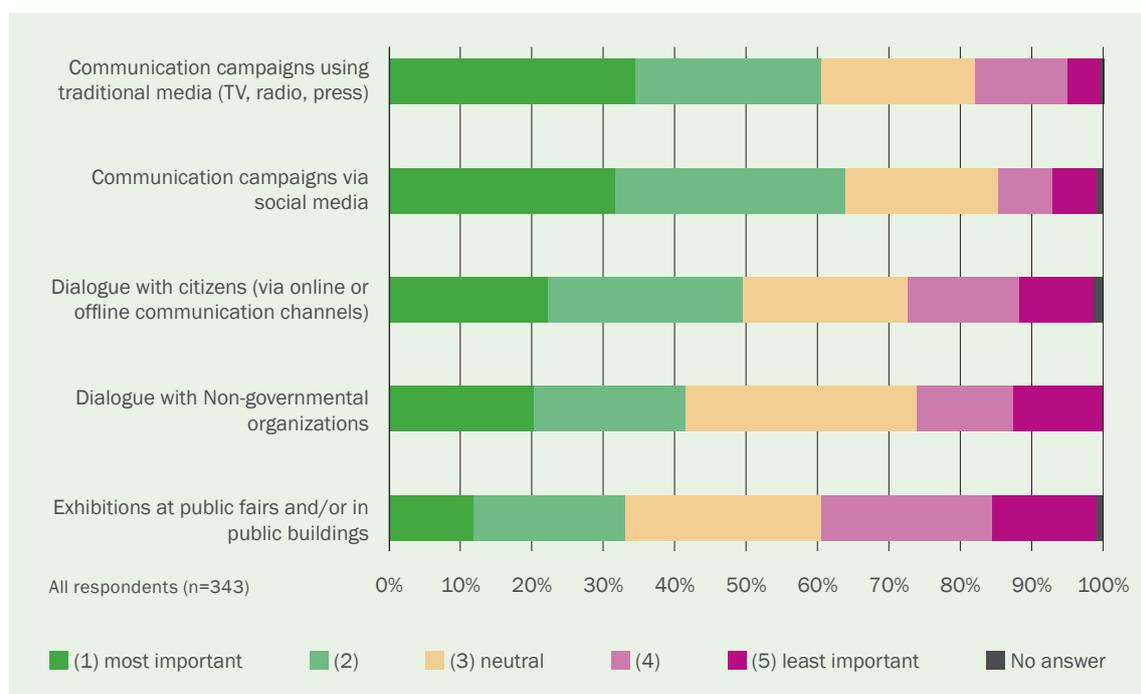
Figure 19: Desirable communication measures

4.8 Desirable education measures

The German Bioeconomy Council's 2015 Delphi survey identified education as key to the further development of the bioeconomy, particularly because of the way that natural and engineering sciences and economic and social sciences influence each other. With this in mind, survey respondents would spend more of the total government funding for bioeconomy on education than on communication. Again, the clusters differ. BasicPrims would invest the highest percentage (27%). HighTech countries would invest the smallest amount (16%).

University courses ranked highest
Courses at universities for undergraduates and graduates (43%) and "teach the teacher" programs (35%) were scored by respondents as the education measures thought to have the greatest effect (Figure 20). Open learning platforms were thought to have the least effect (13%). Interestingly, teach the teacher campaigns are viewed as less important by the BasicPrim countries but not by the HighTech countries. This observation might reflect the opportunities for education in general, and vocational training in particular, within these countries. With re-

gard to the open learning platforms, BasicPrims and HighTech countries gave these the lowest ratings. Access to the Internet or the value attached to such platforms might be the key to this observation.

Comments underline the importance of vocational training courses in general and also for important actors, such as journalists or executives, not affiliated to bioeconomy. Best practice examples may also serve as an appropriate education measure. Further remarks included temporary studies and cooperative schemes.

4.9 Important future investments

Research drives innovation. Innovation drives product development. Public research money fuels research. When asked about research goals important to future bioeconomy strategies in the respondents' countries, the answers painted a clear picture (Figure 21).

Technological advance of prime interest
Taking a closer look at different research goals, it seems obvious that public research funds should invest a larger proportion of future money in technological innovations, high-tech strategies and
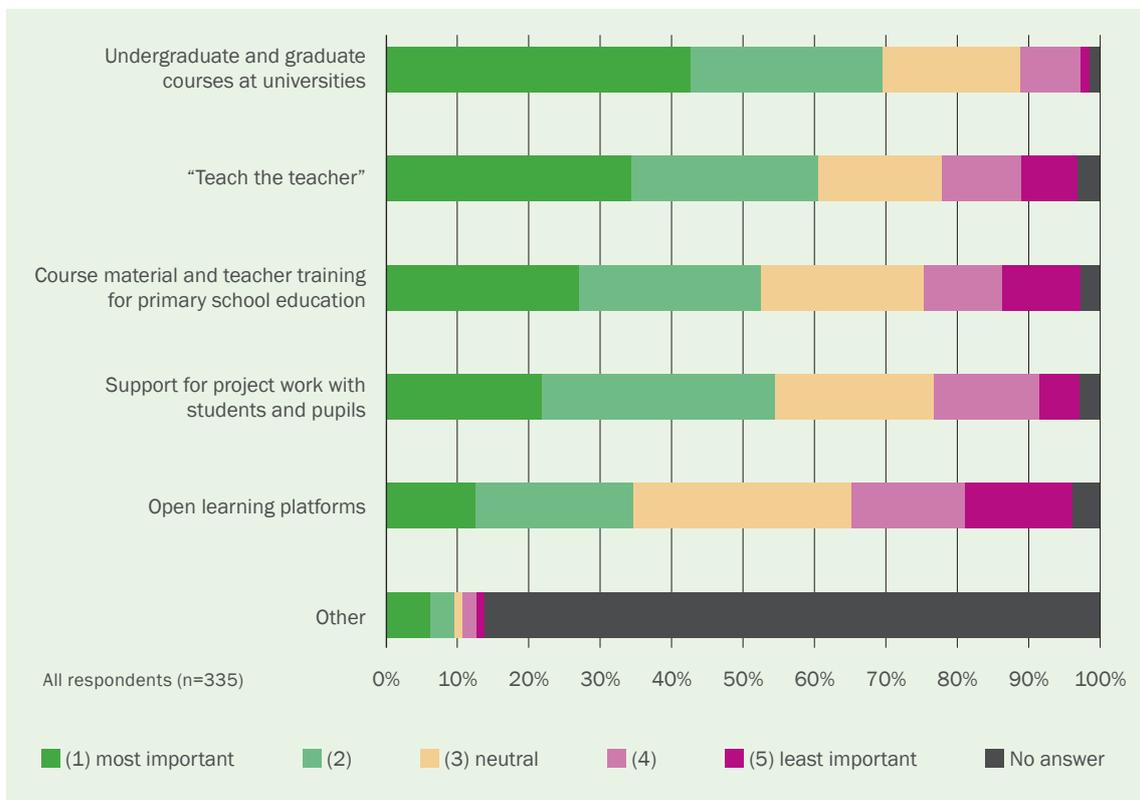
Figure 20: Desirable education measures
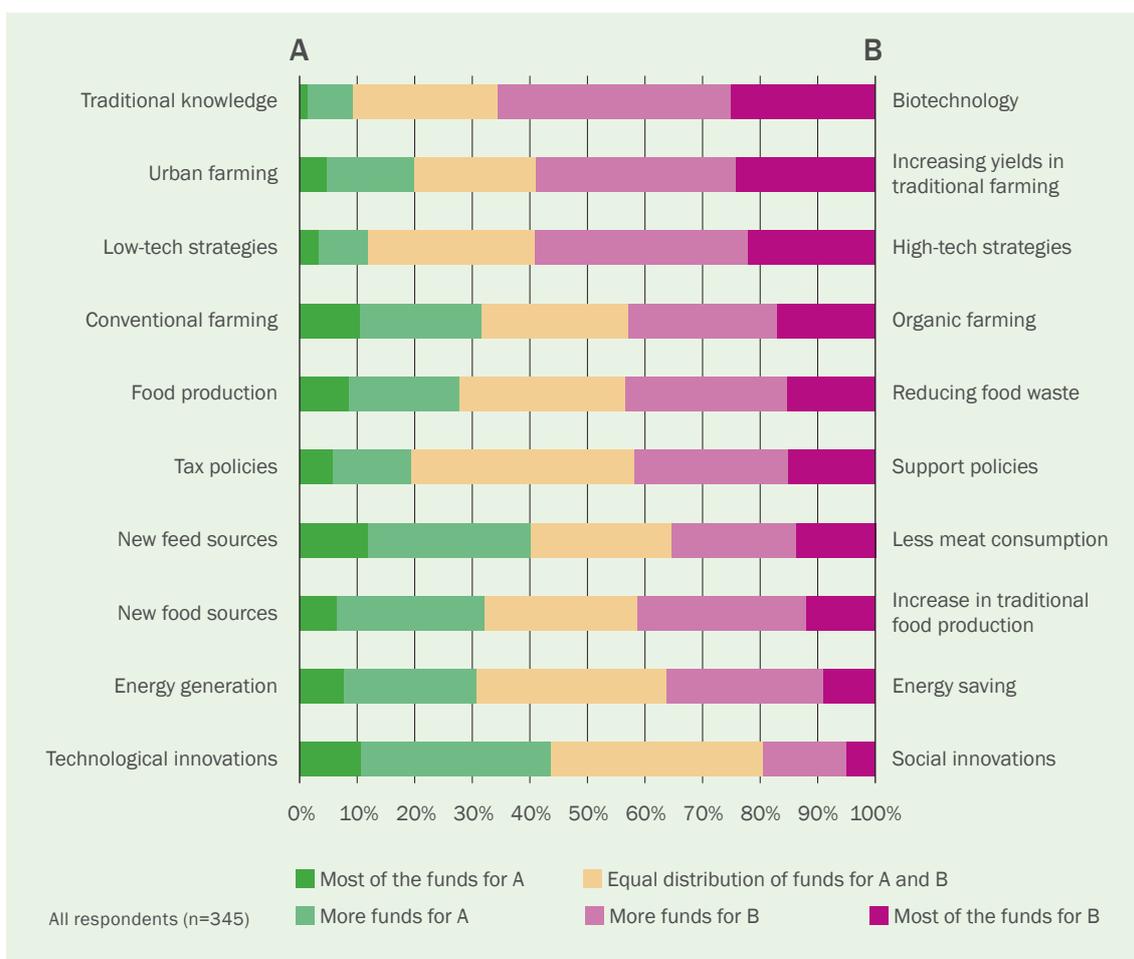
Figure 21: Funding for important research goals for future bioeconomy strategies

biotechnology. These goals are favored over social innovations, low-tech strategies and traditional knowledge – irrespective of the country.

Conventional farming as a mainstay
Conventional farming will maintain its role as a mainstay for bioeconomy in the future. Organic farming, however, will become an integral part of future agriculture. Funds to increase yields in traditional farming are especially important for the BasicPrim and AdvancedPrim countries. In contrast, so far, urban farming appears to be a playground for the highly developed countries.

Food production relevant for developing countries
The still-developing countries consider that increasing traditional food production is very important. They are more interested in new feed sources than reducing meat consumption. This is not surprising, as people in developing countries still need to increase their calorie intake and a rising middle

class views meat consumption as part of its success story. Consuming less meat, however, is high on the agenda of the developed countries and EU officials. The highly developed countries also prefer to explore new food sources. High marks are also given to money, which is aimed at reducing food waste.

Support policies preferred
With regard to different types of policies, the respondents clearly rank support policies as more important than tax policies. One explanation for this observation might be that supporting actions possibly reach a larger number of consumers, companies and producers.

Overall, this picture matches the other observations of this survey in that primary needs for food, feed and energy should be met first and are therefore a major aim of the less developed countries. One way forward, for the more developed countries as well, is their faith in technological advances.

5 Outlook

National bioeconomy strategies have been published by several nations around the globe. There is, of course, a difference between the developmental stages of the various countries, their specific needs and their corresponding desire to advance the transformation from a fossil-based economy towards an economy based on renewable resources.

Nevertheless, within the next 20 years the maturing bioeconomy will succeed in the energy, agricultural, and the food & feed sector. In addition, several new products, such as chemicals based on renewable materials, will reach the market. New technologies, such as genome editing in plant breeding, metabolic engineering or further digitalization of the primary sector, will pave the way to enhancing further developments.

This trust in future innovation is noticeable across all respondent groups. A majority of participants stress the need to develop novel (biobased) products and to optimize the current agricultural status quo in order to feed the world population. Most often, respondents want to confront this challenge by increasing yields and optimizing land use with the help of technological advances. The strong belief in innovation is confirmed when looking at the SDGs, which were ranked as most essential in the context of future bioeconomy success stories. The answer is SDG 9 on industry, innovation and infrastructure.

Many experts stressed the need to reduce waste or better valorize it. They even viewed the reduction of food waste and losses along the supply chain as the most important approach to feeding the growing world population. Whether this is a realistic assumption should be analyzed in a global assessment of food waste. Research could also be used to develop better supply chain management and holistic strategies for approaching the future bioeconomy.

Updated bioeconomy strategies should deal with conflicting goals and their implication for future developments at an early stage. Regional aspects should also be borne in mind as they may reduce the challenges when moving forward.

Since SDG 12 on responsible consumption and production received most support from HighTech countries, future research could be targeted at whether this willingness to refrain from eating meat exists only among experts or also when asking the general public. At the same time, it might be worthwhile to enquire whether new innovations, such as in-vitro meat, are regarded as acceptable alternatives.

The necessary policies should complement these efforts but they should bear in mind that the needs of the less developed and emerging countries differ from those of the industrialized, technologically highly developed countries.

In line with the observations of this global expert survey, future efforts should particularly include a triangle of educational, financial and political measures to promote the bioeconomy's market success.

Knowledge and funding were assessed as crucial to advancing the bioeconomy. Sufficient funding and access to capital should therefore be high on national agendas, e.g. for basic and applied research. Know-how should be shared between industrialized and developing countries, professionals should be trained, people educated. Fossil fuel subsidy schemes could be updated, and biobased procurement policies or export-promoting policies should be available where helpful.

Attention should also be paid to adequate funding for communication and education efforts.
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6 References

1. Cuhls, K.[1], Kayser, V.[1], Grand, S.[1], Hamm, U.[2], Reisch, L.[2], Daniel, H.[2], El-Chichakli, B.[3], Dieckhoff, P.[3] (2015)
Global visions for the bioeconomy – An international Delphi-study
[1]Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, Germany
[2]German Bioeconomy Council
[3]Office of the German Bioeconomy Council, Berlin, Germany

2. Kuckartz, U. (2014)
Qualitative text analysis: A guide to methods, practise and using software
London, Sage Publications

3. Miles, M. B., Huberman, A. M. (1984)
Qualitative data analysis: A sourcebook of new methods
Beverly Hills, Sage Publications

4. Yin, R. K. (2015)
Case study research: Design and methods (5th ed.)
Thousand Oaks, Sage Publications

5. Krippendorff, K. (2013)
Content analysis: An introduction to its methodology (3rd ed.)
Los Angeles, Sage Publications

6. Börner, J., Kuhn, A., von Braun, J. (2017)
Bio-economy in developing countries (Policy Brief No. 25)
University of Bonn, Center for Development Research (ZEF), Bonn, Germany

7. http://biooekonomierat.de/en/bioeconomy/

8. Directorate-General for Research and Innovation (2012)
Innovating for sustainable growth: A bioeconomy for Europe
European Commission, Brussels, Belgium

9. Dieckhoff, P., El-Cichakli, B., Patermann, C. (2015)
Bioeconomy policy (Part I) – Synopsis and analysis of strategies in the G7
Office of the German Bioeconomy Council, Berlin, Germany

10. Fund, C., El-Cichakli, B., Patermann, C., Dieckhoff, P. (2015)
Bioeconomy policy (Part II) – Synopsis of national strategies around the world
Office of the German Bioeconomy Council, Berlin, Germany

11. Biber-Freudenberger, L. (2017)
Chances and risks of bio-economy for human development: Towards an evidence-based dialogue
Proceedings of the international scientific conference Humboldt-Kolleg "Science and science management for sustainable development", Cairo, Egypt

12. Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., Meybeck, A. (2011)
Global food losses and food waste – Extent, causes and prevention
FAO, Rome, Italy

13. Directive (EU) 2015/720 of the European Parliament and of the council amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags (2015)
Official Journal of the European Union

7 Annex

Questionnaire

Global Expert Survey of the German Bioeconomy Council

Dear Expert,

We invite you to take part in a Global Expert Survey on future developments in the bioeconomy.

The survey results will be presented to political leaders at the Global Bioeconomy Summit 2018 in Berlin/ Germany. Taking part gives you a chance to **win one of three travel grants to the GBS2018** and you will also receive a pre-publication of the results.

The survey takes about 30 minutes to complete. Please answer by **November 17th, 2017**.

When answering the survey, you can navigate backward and forward between questions. You can leave the survey at any time and return to it at your own convenience. Clicking ,next' or ,previous' or ,save and resume later' saves your answers.

BIOCOM AG is organizing this expert survey on behalf of the German Bioeconomy Council, an independent advisory body. All your personal data will be treated with strict confidentiality. All results will be presented in such a way that it will be impossible to identify individual respondents.

If you have any questions about the survey, please contact the project manager, Dr. Sebastian Delbrück (s.delbrueck@biocom.de, tel.: +49-30-264921-64).

Thank you on behalf of the German Bioeconomy Council for taking part in the survey. We look forward to the results.

Prof. Dr. Christine Lang   Prof. Dr. Dr. h.c. Joachim von Braun
Co-chair Bioeconomy Council   *Co-chair Bioeconomy Council*

✽ = Compulsory questions

✽ **1. Are you engaged in research, development, business or policymaking related to the bioeconomy?**
◯ yes
◯ no

✽ **2. Are you a member of a formal/governmental bioeconomy advisory council?**
◯ yes
◯ no

✽ **3. Which of the following best describes your role? Select one only.**
◯ researcher/lecturer at a public institution (university, research institute)
◯ policy maker/public official/public administration staff
◯ owner/manager of a private company
◯ researcher in a private company/a corporation
◯ representative of a civil society organization/NGO
◯ other, please specify ....

✽ **4. Which is your main sector of operation?**

◯ agriculture   ◯ biotechnology
◯ forestry   ◯ health, pharma
◯ fishery   ◯ food, nutrition
◯ energy   ◯ wood and paper manufacturing
◯ chemistry   ◯ other, please specify ....

✽ **5. What will be the three most promising bioeconomy success stories in your country over the next 20 years? Please indicate, which of the UN Sustainable Development Goals (SDGs) they will affect.**
SDGs: 1 (No poverty), 2 (Zero hunger), 3 (Good health and well-being), 4 (Quality education), 5 (Gender equality), 6 (Clean water and sanitation), 7 (Affordable and clean energy), 8 (Decent work and economic growth), 9 (Industry, innovation and infrastructure), 10 (Reduced inequalities), 11 (Sustainable cities and communities), 12 (Responsible consumption and production), 13 (Climate action), 14 (Life below water), 15 (Life on land), 16 (Peace, justice and strong institutions), 17 (Partnerships for the goals)

❗ Please fill in at least one answer
Success story 1: ....   SDGs: ....
Success story 2: ....   SDGs: ....
Success story 3: ....   SDGs: ....

✱ 6. One of the most challenging global questions is how to feed the growing world population in the future. Choose <u>three</u> approaches in order of importance that will provide a solution (1 "most important" to 3 "least important").

Double-click or drag-and-drop items on the left to move them to the right with the most important at the top followed by your other choices. Please select 3 answers.

.... increase crop yields using innovations (new plant breeds and seeds)

.... increase crop yields using improved production methods

.... reduce food waste and losses along the supply chain

.... open up new sources of food production such as algae, insects, in-vitro meat, aquaculture products, etc.

.... reduce meat consumption in industrialized countries

.... produce food in towns, e.g. roof and vertical farming, aquaponics

.... use edible biomass primarily for food

.... increase land available for crops by converting grassland and/or wilderness

.... increase the nutritional value of food products

.... reduce and optimize the use of water for agriculture

.... other (please specify below)

If "yes", please specify below: ....

✱ 7. About 10–15% of the worldwide arable land (1.5 bn hectares) is not used for food production but for bioenergy crops or crops for bio-industrial use. Should bioeconomy strategies deal with this?

◯ yes

◯ no

If "yes", please list your suggestions below: ....

✱ 8. About one third of the global crop land is used to produce feed for meat, milk and egg production, mainly in industrialized and emerging countries. There is criticism that world market prices for plant-based food therefore increase and make the situation worse for the poor. Should bioeconomy strategies deal with this?

◯ yes

◯ no

If "yes", please list your suggestions below: ....

✱ 9. There is criticism that virgin forests, e.g. in South East Asia and Latin America, are converted into agricultural land to produce e.g. palm oil, soybeans or beef for export. Should bioeconomy strategies deal with this?

◯ yes

◯ no

If "yes", please list your suggestions below: ....

✳ **10. Characterization of technologies for a sustainable Bioeconomy**

Technologies drive transformation in the bioeconomy. List up to five characteristics of these technologies you think are important to make sustainable bio-based transformation possible (e.g., create new functionalities, increase productivity in bio-based primary sectors, etc.).

❗ Please fill in at least one answer

1. ....
2. ....
3. ....
4. ....
5. ....

✳ **11. Promising technology fields for a sustainable bioeconomy**

List up to five promising technology fields that could enable bio-based transformation (e.g., enzyme technologies, bioinformatics, algae technologies, etc.)

❗ Please fill in at least one answer

1. ....
2. ....
3. ....
4. ....
5. ....

✳ **12. Look at the following policy measures. How important are they in the future to the bioeconomy's market success in your country?**

a) Promoting Innovation

	totally unimportant			neutral			very important
Social innovation, e.g. open innovation, citizen science	○	○	○	○	○	○	○
Private R&D	○	○	○	○	○	○	○
Traditional knowledge and low-tech innovations	○	○	○	○	○	○	○
Public-private partnerships	○	○	○	○	○	○	○
Private R&D	○	○	○	○	○	○	○

b) Supporting infrastructure and capacity building

	totally unimportant			neutral			very important
Capacity building, e.g. trainings for professionals	○	○	○	○	○	○	○
Bioeconomy education programs (incl. masters and doctoral programs)	○	○	○	○	○	○	○
Pilot and demonstration facilities	○	○	○	○	○	○	○
Cluster development	○	○	○	○	○	○	○

c) Supporting commercialization

	totally unimportant			neutral			very important
Access to capital for biobased companies	○	○	○	○	○	○	○
Export promotion policy	○	○	○	○	○	○	○
Development and marketing efforts, e.g. feasibility studies	○	○	○	○	○	○	○
Subsidies for (increased) production and use of renewable resources	○	○	○	○	○	○	○

d) Supporting the demand-side

	totally unimportant			neutral			very important
Biobased public procurement policy	○	○	○	○	○	○	○
Certification and labels explaining a product's life cycle impact, e.g. footprint	○	○	○	○	○	○	○
Consumer information and communication campaigns	○	○	○	○	○	○	○
Tax incentives	○	○	○	○	○	○	○
Ban of fossil-based products, e.g. plastic bags	○	○	○	○	○	○	○

e) Ensuring conditions that encourage the bioeconomy

	totally unimportant			neutral			very important
Removal of fossil fuel subsidies	○	○	○	○	○	○	○
Carbon tax	○	○	○	○	○	○	○
Regulations on biodiversity protection and ecosystem regeneration	○	○	○	○	○	○	○
Circular economy regulations (recycling quotas, use of byproducts, eco-design, life-cycle assessment of patents)	○	○	○	○	○	○	○

f) Promoting Good Governance

	totally unimportant			neutral			very important
Inter-ministerial and inter-regional cooperation	○	○	○	○	○	○	○
Monitoring and measuring activities	○	○	○	○	○	○	○
Public reporting and multi-stakeholder dialogue	○	○	○	○	○	○	○
Learning and adaptive policy	○	○	○	○	○	○	○
Bioeconomy advisory council	○	○	○	○	○	○	○

g) Improving international collaboration in the bioeconomy

	totally unimportant			neutral			very important
Harmonization in international trade and policy frameworks	◯	◯	◯	◯	◯	◯	◯
Knowledge sharing between industrialized and developing countries	◯	◯	◯	◯	◯	◯	◯
Private investment in developing countries	◯	◯	◯	◯	◯	◯	◯
International monitoring, e.g. wsatellite tracking	◯	◯	◯	◯	◯	◯	◯

13. Many people do not understand the concept of bioeconomy or how it could improve quality of life without using up the world's natural resources. So far, attempts to communicate this have been weak but they could be key to its further development.

✳ a) What percentage of the total government funding for bioeconomy would you use for public communication and/or citizen engagement?

.... % of total governmental expenditures for bioeconomy development

b) Please list in order of importance the communication measures you think would have the greatest effect.

	most important		neutral		least important
exhibitions at public fairs and/or in public buildings	◯	◯	◯	◯	◯
communication campaigns via social media	◯	◯	◯	◯	◯
dialogue with NGOs	◯	◯	◯	◯	◯
communication campaigns using traditional media (TV, radio, press)	◯	◯	◯	◯	◯
dialogue with citizens (via online or offline communication channels)	◯	◯	◯	◯	◯

14. The German Bioeconomy Council's 2015 Delphi survey identified education as the key to further development of the bioeconomy, particularly because of the way that natural and engineering sciences and economic and social sciences influence each other.

✳ a) What percentage of the total government funding for bioeconomy would you use for education?

.... % of total governmental expenditures for bioeconomy development

b) Please list in order of importance the education measures you think would have the greatest effect.

	most important		neutral		least important
course material and teacher training for primary school education	○	○	○	○	○
undergraduate and graduate courses at universities	○	○	○	○	○
support for project work with students and pupils	○	○	○	○	○
open learning platforms	○	○	○	○	○
"teach the teacher"	○	○	○	○	○
Other (please specify below)					

If "other", please specify below: ....

✻ **15. How important to future bioeconomy strategies in your country are the research goals below? Decide how you would invest public research funds in each pair of goals (A and B) shown.**

A	Most of the funds for A	More funds for A	Equal distribution	More funds for B	Most of the funds for B	B
Energy generation	○	○	○	○	○	Energy savings
Food production	○	○	○	○	○	Reducing food waste
Low-tech strategies	○	○	○	○	○	High-tech strategies
Traditional knowledge	○	○	○	○	○	Biotechnology
Technological innovations	○	○	○	○	○	Social innovations
Urban farming	○	○	○	○	○	Increasing yields in traditional farming
Conventional farming	○	○	○	○	○	Organic farming
New food sources (e.g. insects, algae, etc.)	○	○	○	○	○	Increase in traditional food production
New feed sources	○	○	○	○	○	Less meat consumption
Tax policies	○	○	○	○	○	Support policies

✻ **16. Would you like to take part in the Global Bioeconomy Summit 2018 in Berlin, Germany?**
○ Yes
○ No
○ No answer

17. Which topics would you like to see on the Summit's agenda? ....

18. Your comments ....

Thank you for completing this survey.

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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