



## Bioeconomy perception by students of different study programs – study from Slovakia

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### Abstract

The paper builds on previous international research done by Masiero et al. (2020). It applies on Slovak national level and expands the previous study with different study programs. The societal transformation towards bioeconomy provides an opportunity for changing current economy and societies into more sustainable ones with mitigation of the environmental pressures at hearts. Such societal transition requires involvement of all stakeholders in bioeconomy discussion and decision-making process and studying their perceptions of bioeconomy. Amongst all the stakeholders, future generation is particularly important, as it is important to understand bioeconomy perception by the generation of stakeholders that will manage this area in the near future. For that reason, we focus our attention on students of three bioeconomy related areas at the Technical University in Zvolen (forestry studies, wood processing studies and natural resources management studies). We were able to identify significant differences in bioeconomy perception between analyzed categories. The familiarity with the concept is quite high, as more than two thirds have heard about bioeconomy before the survey was conducted. As the main information sources were selected news, university courses and social media. The study program had a greater impact on perceived importance of forests within bioeconomy than the type of study. Overall, students perceive development of forest-based bioeconomy as favouring sustainable forest management.

**Key words:** bioeconomy; perception; higher education; university students

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### 1. Introduction

In the last decade, bioeconomy is becoming an important and very popular term, mainly due to its potential to tackle societal problems, such as growing population, climate change, natural resources scarcity, food security, poverty or health (McCormick & Kautto 2013; European Commission 2018; Bugge et al. 2016), as it is concept focused on sustainability, resource utilization efficiency and use of renewable natural resources in production of food, energy, materials and other products (Schmidt et al. 2012). All of these problems are related to population growth – there are forecasts implying increase in global population by 2.3 billion people by 2050 (Glenn & Florescu 2015). Above-mentioned is resulting in increased demand for natural resources and commodities, while there are projections showing that a doubling the economy results will lead to increased pressure on natural resources (Biber-Freudenberg 2018) and increased emis-

sion of greenhouse gas by 80% (Philp 2015).

Bioeconomy presents a way for us to change the current economy into more sustainable one, that will ensure growth while contemporaneously mitigating the pressure on natural resources utilization. The character of the bioeconomy concept is cross-sectoral, focusing mainly on cooperation of biotechnological sector, pharmaceutical sector, agriculture (Enriquez 1998), forestry, fisheries, food and energy production, wood processing sector and chemical sector (EC 2012). The concept primarily comprises of two spheres – life sciences and biotechnology (McCormick & Kautto 2013; Staffas et al. 2013) – although the output from the biotechnology sphere, such as bio-based products, bioenergy, biorefineries, is much easier to distinguish (Richardson 2012). The life sciences sphere of bioeconomy concerns issues like public awareness or societal transformation and its course. When it comes to societal transformation, according to Hardy (2002), today's position of bioeconomy should

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be the same as was the position of fossil-based economy in the 20<sup>th</sup> century. Current position of bioeconomy in respective national strategies over the world differs from one to another (Staffas et al. 2013). Similarities can also be found in these strategies, one of them being the fact that even though these strategies often indicate crucial transformation altering production processes, they do not consider radically changing the current economic system or implementing concepts, such as degrowth (Priefer 2017), but still, the need for a societal transformation is strongly perceived.

For guiding such a huge challenge, as a transformation towards bioeconomy, it is necessary to integrate bioeconomy on a society level which requires involvement of all stakeholders in bioeconomy discussion and decision-making process and studying their perceptions of bioeconomy (Mustalahti 2017). The lack of inclusion of the perspectives of societal actors can lead to a lack of acceptance and engagement with the concept of bioeconomy on a consumer or citizen level (Ramcilovic-Suominen & Pölzl 2016; Kleinschmidt et al. 2018). The concept of bioeconomy then can easily be rejected by the society and thereby become meaningless. Summarizing, scientific studies on the bioeconomy have rarely engaged with societal matters and, thereby, have contributed to the exclusion of societal issues from the agenda and in relation to the bioeconomy (Masiero et al. 2020).

Amongst all the stakeholders, future generation is particularly important. For us to be able to make predictions about future bioeconomy development, it is necessary to understand its perception by the future generation of stakeholders, namely students of bioeconomy related areas. In the paper, we focus our attention on students of forestry studies, wood processing studies and natural resources management studies, as it covers forest management from its planting, managing to processing. To the date, research related to bioeconomy is mainly biotechnology-oriented (Philp et al. 2013; Philp 2015; Stafford et al. 2020), however, there are couple of studies focusing on perception of bioeconomy in general (Imbert et al. 2019). On the national level, there is one study aiming at assessing the potential of bioeconomy in Slovakia (Navrátilová et al. 2020) – a country that to this date has not published a specific bioeconomy strategy, but with rich, yet underutilised, bioeconomy potential (mostly forest-based bioeconomy). This study indicates that based on public perception of various kinds of renewable and non-renewable materials, Slovak public perceives the need for transforming the economy towards more sustainable one.

Until now, only little empirical research has been conducted to research the current state of students' perception of bioeconomy (Drejserská 2017; Pätäri et al. 2017; Stern et al. 2018; Golowko et al. 2019; Kylkilahti et al. 2020; Masiero et al. 2020). Current students will be the managers of the future and therefore must be valued as an important target group for bioeconomic issues (Golowko et al. 2019). This paper aims to fill the research gap in

social bioeconomy research, by investigating the perceptions of students as potential future human capital in the bioeconomy.

The aim of this paper is to identify the bioeconomy perception by students of three different bioeconomy-related study programs. For a successful implementation of the bioeconomy, students of bioeconomy related programs should have sufficient knowledge about the topic, be educated in the area well-enough, perceive the concept in a positive way, and acknowledge the need for the societal bioeconomy transformation.

## 2. Materials and methods

Data collection has been performed via a quantitative survey, using a combined data collection of online questionnaire and paper-printed questionnaires targeted at forestry students, wood sciences students and management of natural resources students – including Bachelor (BSc) and Master students (MSc). Online questionnaire was developed in cooperation with the networking project PerForm funded by EFI and distributed via Lime Survey, where it was available in English and Slovak language. The survey was conducted at the Technical University in Zvolen, Slovakia. Data collection was done via Lime Survey between January and June 2019. Link to the survey was sent to the students via students' e-mail, while paper-printed questionnaires were distributed to students during lectures. A common dataset was created once the data collection was finished.

The questionnaire, consisted of open, close-ended, multiple choice and rating scale questions. It was structured into six sections:

1. *“Familiarity with bioeconomy”* – at this point, the bioeconomy definition was not provided. This section aimed at investigating the familiarity of students with the concept of bioeconomy and bioeconomy-related strategies at national and European level.
2. *“Bioeconomy at university”* – the introduction of this section provided a bioeconomy definition (EC, 2012). The section was aimed at identifying whether bioeconomy is mentioned/addressed in study programs, identifying these study programs and the extent to which bioeconomy is addressed.
3. *“Perception of bioeconomy”* – aimed at identifying students' bioeconomy perceptions at both national and European level, identifying aspects and sectors related to bioeconomy and identifying winners/losers related to bioeconomy. In this section, forests and forest-based bioeconomy was significantly considered.
4. *“Problems and opportunities”* – aimed at identifying perceived drivers, problems and opportunities connected to bioeconomy development.
5. *“Bioeconomy: future expectations”* – aimed at identifying the future job expectations of students and their linkage to bioeconomy.

6. “General info on respondent” – aimed at obtaining general information on the respondents, such as age, gender, nationality, and the university of attendance.

Statistical analyses have been conducted by means of Microsoft Excel for basic statistics, largely intended to describe data distribution and trends, as well as descriptive statistics. Data have been analysed with regard to the total sample and for single study program, as well as by distinguishing between BSc and MSc respondents, in order to allow a comparative analysis and check whether differences/similarities are detectable or not.

In total, 398 questionnaires were collected. Composition of the sample is given in Table 1. The sample consists of 44% of female respondents and 55% of male respondents. More than half of the respondents were currently studying in BSc study program (58%) and 42% were studying in MSc study program. Almost half of the respondents (47,5%) studied at the Faculty of Wood Sciences and Technology (FWST), roughly one-third of respondents (31,2%) studied at the Faculty of Forestry (FF) and 21,3% studied Economics and Management of Natural Resources (EMNR).

### 3. Results

#### 3.1. Familiarity with bioeconomy

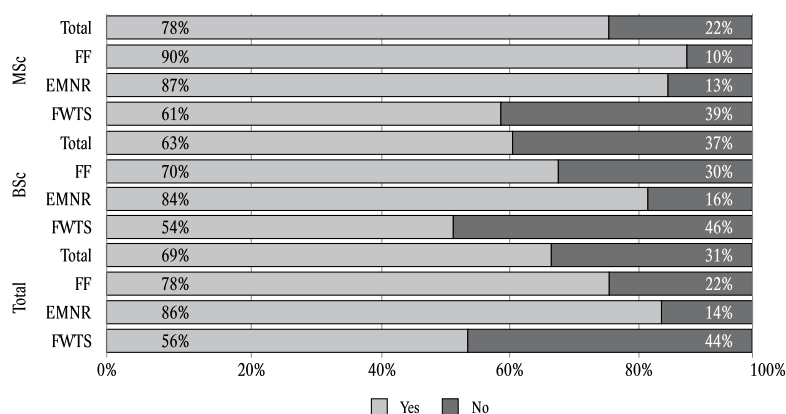
In the following section, we focused on respondents' familiarity with bioeconomy. Results showed that more

than two-thirds (69%) of all respondents have heard about bioeconomy (Fig. 1). Most of the students of EMNR study program, about 86% of them, have heard about bioeconomy. The percentage of respondents who have heard about bioeconomy decreases from students of EMNR (86%) to forestry students (about 78%) and finally to wood sciences students (56%). Regarding BSc study programs, results are following: 84% of EMNR students, 70% of forestry students and 54% of FWTS students have heard about bioeconomy. In MSc study programs, the results are following: 90% of forestry students, 87% of EMNR students and 61% of wood sciences students have heard about bioeconomy. Overall, we can see a clear upward trend in the number of students who heard about bioeconomy from students of BSc study programs to students of MSc study programs, the variance being 15%.

The results further showed main sources of information about bioeconomy. The main three sources of information are news (31%), university courses (31%) and social media (22%) (Fig. 2). These three main sources represent more than 80% of information sources in all examined categories of students, only the order of the most often identified sources differs across study programs. For students of BSc study programs, the order of the main three sources is: news (36%), social media (25%), university courses (21%). For students of MSc study programs, the order of the main three sources is: university courses (43%), news (25%), social media

**Table 1.** Determination of the respondent sample sizes. The required sample sizes were calculated for a 5% margin and 90% confidence level (CL). The realized sample sizes corresponded to the numbers of completed and returned questionnaires.

		FF	FWTS	EMNR	Total
Population size		539	1803	193	2 535
Required Sample Size		181	236	113	245
Realized Sample Size		124	189	85	398
Real Margin of Error (CL 90%)		6.5%	5.7%	6.7%	3.8%
Of which (per gender)	Female	25	92	58	175
	Male	99	97	27	223
Of which (per study program)	BSc	73	127	31	231
	MSc	51	62	54	167
Respondents, %		31.2%	47.5%	21.3%	100.0%
Of which (per gender)	Female	6.3%	23.1%	14.6%	44.0%
	Male	24.9%	24.3%	6.8%	56.0%
Of which (per study program)	BSc	18.3%	31.9%	7.8%	58.0%
	MSc	12.8%	15.6%	13.6%	42.0%



**Fig. 1.** Respondents who have (yes)/haven't (no) heard about bioeconomy: figures for all respondents and per attended program.

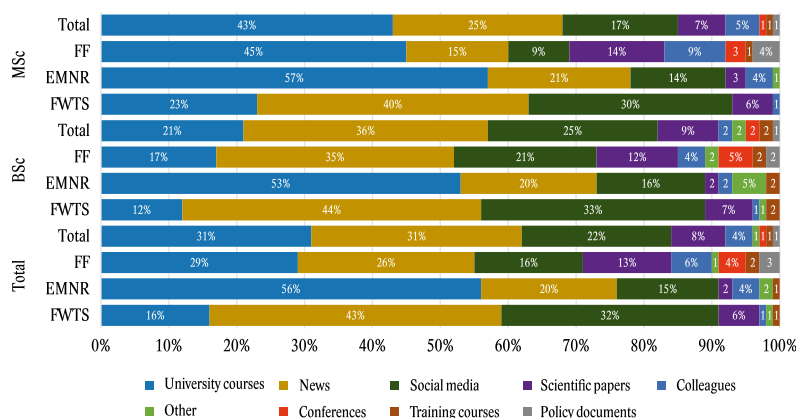


Fig. 2. Main information sources on bioeconomy for respondents.

(17%). Results also show that almost half of the wood sciences students identified news as the main source of information. However, more than a half of the EMNR students identified university courses as the main source of information. The trend is the same for BSc students as for MSc students of these study programs. If we look at forestry students, we can see a greater variance in identified information sources. The main information sources for forestry students are university courses (29%), news (26%), social media (16%), and they gain information from scientific papers (13%), colleagues (6%) and conferences (4%) more often compared to FWTS and EMNR students. For BSc forestry students the main sources are news (35%), social media (21%), university courses (17%) and scientific papers (12%). The main sources for MSc forestry students are university courses (45%), news (15%), social media (14%), scientific papers (9%), and colleagues (9%).

### 3.2. The perceived role and importance of forest resources within bioeconomy

Students were asked to identify how given sectors contribute to the bioeconomy at the European and national level (Fig. 3) on the scale 1–5 (1=not at all, 5=very often). Results show, that the perceived contribution of different sectors to bioeconomy is almost the same for all categories of students. Students acknowledged the contribution of sectors at the European level more than at the national level. At the European level, students identified bioenergy, biofuels and forestry sectors as “often” (average 4) contributing to bioeconomy. Agriculture sector is seen as “less often” (average 3.5) contributing to bioeconomy. According to students, following sectors are seen as “less often” (average 3) contributing to bioeconomy: pulp and paper, livestock, food and beverages, fishery and aquaculture and feed. The average value 2.5 (from “less often” to “seldom”) of bioeconomy contribution reached tourism and recreation, education, chemistry and pharmaceutical sectors. A seldom contribution of

textile sector and building and constructions sector is perceived by students.

In the next question, students were asked to identify their perceived importance of forestry within bioeconomy at the European and national level. At the European level, students reported higher importance of forestry within bioeconomy than at national level (Fig. 4). Overall, the results showed a greater impact of study program on *Perceived importance of forests within bioeconomy* compared to type of study. Forestry students reported higher importance of forests within bioeconomy than the students of other two study programs. For them, the role of forestry within bioeconomy at both levels (national and European) is “quite important” (value 4). Students of EMNR study program attach a little lower importance to forestry within bioeconomy as forestry students. Finally, students of wood sciences reported lower importance of forestry within bioeconomy compared to students of other two study programs. The range of values in all study programs is from 3.31 to 4.19 (from “neutral” to “less important”).

Next part is dedicated to the extent to which given aspects are currently developed through bioeconomy. According to our results (Table 2), students tend to assess this extent with values ranging between 3 and 4 (“slightly” to “less significant” rate). In total, higher rate was assessed for *efficient use of forest products* (3.65), the *substitution of fossil-based products with forest-based ones* (3.51) and *new uses for an existing product* (3.49). Students of EMNR study program assessed higher values for all given aspects compared to other students.

When we look at Table 3, we can see the agreement or disagreement with given statements concerning forest-based bioeconomy. Students agree that development of forest-based bioeconomy shall try to combine new and traditional knowledge (3.86) and be based on local resources (3.83). We can state that bigger impact on respondents’ answers in this part of questionnaire has the study program compared to the type of study. FWTS and EMNR students think that the development of a forest-based bioeconomy shall mainly be based on local resources. On the contrary, FF students think that the

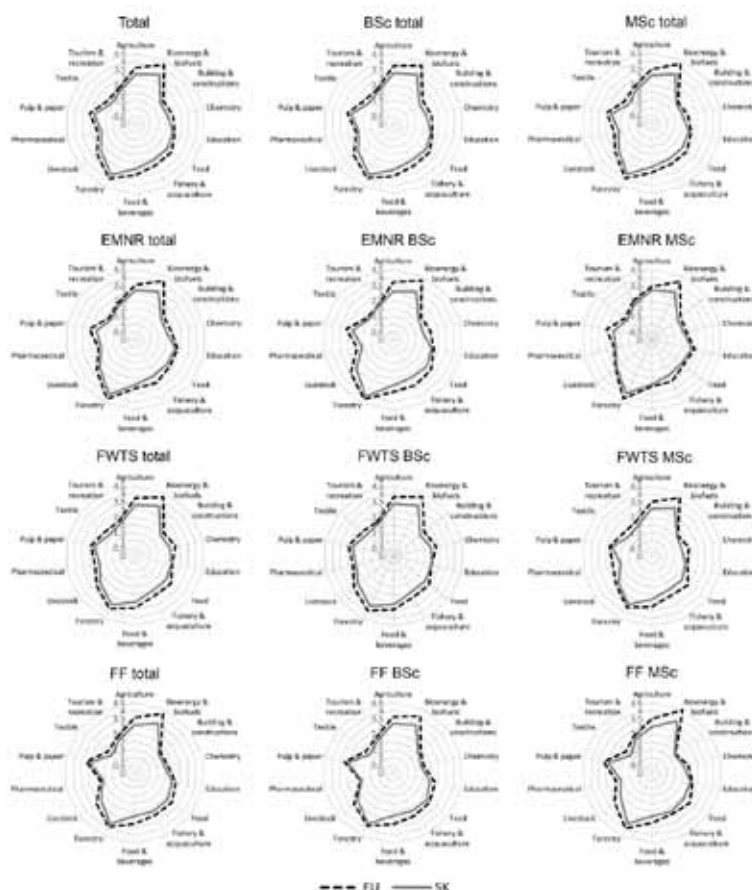


Fig. 3. Perceived contribution of different sectors to bioeconomy at the European and national scale.

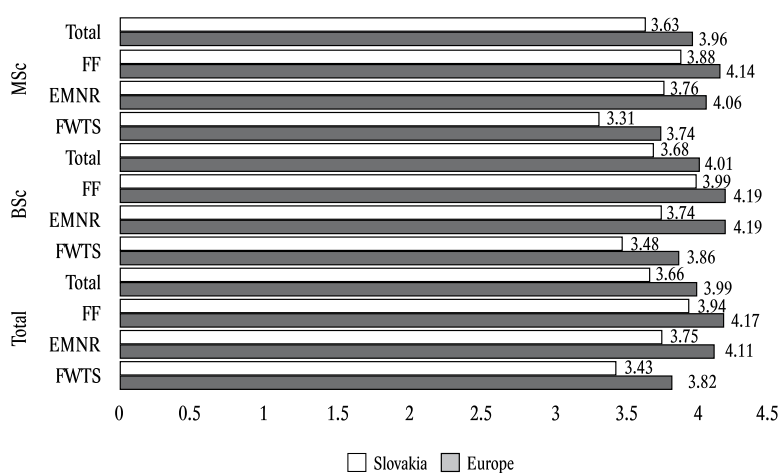


Fig. 4. Perceived importance of forests within bioeconomy at the European and national scale.

Table 2. Extent to which given aspects/issues are currently developed through bioeconomy.

	FF			FWTS			EMNR			Total	
	BSc	MSc	Total	BSc	MSc	Total	BSc	MSc	Total	Average	St. dev.
N.	73	51	124	127	62	189	31	54	85		
New products & technologies	2.85	3.12	2.96	3.30	3.19	3.27	3.42	3.45	3.44	3.21	1.01
Improved products	3.22	3.24	3.23	3.46	3.52	3.48	3.48	3.74	3.65	3.44	0.93
Efficient use of forest products	3.67	3.88	3.75	3.58	3.44	3.53	3.71	3.80	3.76	3.65	1.05
New uses for existing products	3.33	3.55	3.42	3.54	3.27	3.45	3.65	3.68	3.67	3.49	0.97
Substitution of fossil-based products with forest-based ones	3.50	3.63	3.55	3.51	3.35	3.46	3.73	3.44	3.55	3.51	1.13
Valuing of multiple services/products offered by forests	3.11	3.42	3.24	3.16	3.03	3.12	3.35	3.31	3.33	3.20	1.08



**Table 3.** Agreement/Disagreement with selected statements on forest-based bioeconomy.

N.	FF			FWTS			EMNR			Total	
	BSc	MSc	Total	BSc	MSc	Total	BSc	MSc	Total	Average	St. dev.
73	51	124	127	62	189	31	54	85			
A. The development of a forest-based bioeconomy shall:											
Be technology-driven	3.53	3.35	3.46	3.38	3.39	3.38	3.61	3.54	3.56	3.44	0.91
Be product-oriented	3.42	3.33	3.39	3.11	3.27	3.16	3.35	3.41	3.39	3.28	0.86
Be service-oriented (e.g. ecosystem services)	3.63	3.76	3.68	3.58	3.76	3.64	3.74	3.8	3.78	3.68	0.77
Be based on local resources	3.89	3.86	3.88	3.82	3.66	3.77	4	3.87	3.92	3.83	0.83
Be based on natural resources (local or not)	3.33	2.84	3.13	3.34	3.40	3.36	3.48	3.31	3.38	3.29	1.12
Try to combine new and traditional knowledge	4.15	3.86	4.03	3.70	3.85	3.75	3.9	3.85	3.87	3.86	0.89
B. The development of a forest-based bioeconomy will:											
Promote employment opportunities	4.25	3.80	4.07	3.76	3.87	3.80	3.81	3.83	3.82	3.89	0.92
Favour sustainable forest management	4.29	4.16	4.24	3.84	4.03	3.90	4.32	4.15	4.21	4.07	0.90
Promote forest management at the local scale	3.93	3.94	3.94	3.80	3.71	3.77	3.67	3.87	3.80	3.83	0.89
Promote forest management (no matter at which scale)	3.38	3.33	3.36	3.37	3.29	3.34	3.81	3.6	3.67	3.42	1.02
Lead to increased deforestation/forest degradation	2.10	2.14	2.11	2.47	2.31	2.42	2.29	2.69	2.54	2.35	1.13
Increase people's awareness of environmental and forestry issues	3.78	3.78	3.78	3.68	3.68	3.68	3.97	4.13	4.07	3.79	0.91

development of a forest-based bioeconomy shall mainly try to combine new and traditional knowledge.

On the other hand, students don't agree that development of forest-based bioeconomy will lead to increased deforestation (2.54) and they think that the development of a forest-based bioeconomy will favour sustainable forest management (4.07). When assessing the differences in responses based on study programs, no significant differences occurred. The same applies for individual types of study.

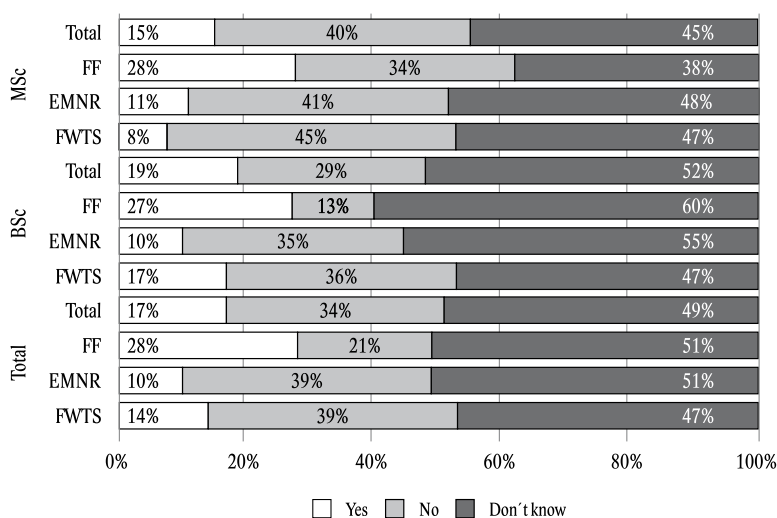
### 3.3. Bioeconomy: future expectations

The last section was aimed at investigating future expectations regarding job position and job creation within the bioeconomy. Two questions were answered: "Will the development of a forest-based bioeconomy help finding the desired job position?" (Fig. 5), "Will the development of a forest-based bioeconomy help creating more job opportunities in general?" (Fig. 6).

When dividing students into study programs, we can notice that 28% of forestry students think that development of forest-based bioeconomy will help them in find-

ing a job. On the other hand, only 10% of EMNR study program students have answered "yes" to this question. In MSc study programs, students are more likely to be decisive and indicate less "I don't know" than students at BSc level. However, the most answers "yes" were indicated by forestry students, 28% for MSc respondents and 27% for BCs respondents. In general, most of the respondents have answered "I don't know" to this question, followed by "no", and "yes" at the last place.

Regarding the question whether the development of a forest-based bioeconomy will lead to increased job opportunities, respondents indicate more positive and less undecided replies than for the previous question: about 59% of them gave a positive answer, just 8% a negative one and about 33% an undecided one (Fig. 6). For all students, the rate of positive replies is higher than 50%. However, the lowest rate of positive answers report students of FWST and these students are the most undecided, too (54%). The most optimistic respondents are the EMNR students in BSc study (71% "yes") and students of FF in MSc study (63% "yes"). In general, the incidence of positive answers is higher among BSc respondents than MSc respondents.

**Fig. 5.** Will the development of a forest-based bioeconomy help to find your desired job position?

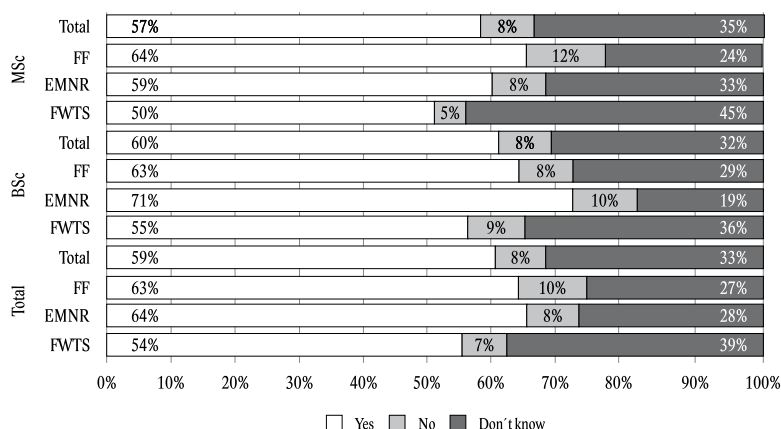


Fig. 6. Will the development of a forest-based bioeconomy help creating more job opportunities in general?

#### 4. Discussion

The concept of bioeconomy has recently received an increasing amount of attention in sustainability-related research across disciplines (Bugge et al. 2016). The importance of perceptions and the inclusion of citizens has been highlighted by several authors (Ramcilovic-Suominen & Pölzl 2016; Mustalahti 2017; Kleinschmidt et al. 2018; Masiero et al. 2020). Building human capital is crucial for the societal acceptance and for safeguarding enough human capital for bioeconomy (Bejinaru et al. 2018). Among future stakeholders, university students will be centre-stage for the development and implementation of a bioeconomy as future decision makers and a key future workforce shaping and enabling it (Masiero et al. 2020). Our results showed that in Slovakia more than two-thirds (69%) of all respondents have heard about bioeconomy, which is a good sign and is in line with European trends (Masiero et al. 2020). Contrary to Drejerska et al. (2017), where the majority of the students in Poland did not hear about bioeconomy.

Regarding the source of information about bioeconomy, the majority of the students stated they heard about the bioeconomy from the news, university and social media. This was surprising because universities should be the first to provide information about new emerging trends. Overall, in Europe, students obtain the most information from university courses (Masiero et al. 2020). In Poland, for example, a vast majority did not hear about this concept at the university (Drejerska et al. 2017). For Slovakia, this was a surprising result, because recent research (Navrátilová et al. 2020) showed, that there is not enough information about the bioeconomy in the media and that Slovakia to this date lacks a bioeconomy strategy, which is currently being developed. Forestry students obtain information from different sources than EMNR and FWST students, which can be explained by the nature of forestry studies putting a high accent on current trend in research.

The forestry sector plays a central role in the bioeconomy and currently is a dominant concept in the politi-

cal discussion on global sustainability transformations (D'Amato 2017). In a bioeconomy, the forestry sector has a role as both a provider of biomass and as a manufacturer of higher-value products (Kleinschmidt et al. 2014). Focusing on the global role of forest-based bioeconomy in creating a more sustainable future, it can attract young talent (Hodge et al. 2017). It is not a surprise, that forestry students acknowledge the role of forestry in the bioeconomy the most important compared to EMNR and FWST students.

When it comes to sectors contributing to the bioeconomy, forestry was ranked only third place after bioenergy and biofuels. This is in line with the (Bugge et al. 2016), where the term bioeconomy is discussed mainly in fields as biotechnology, energy and fuels.

Bioeconomy plays an important role as an employment sector in the EU Member States. A high-quality education system is a prerequisite to sustainable and transformational efforts as well as transparent, participative processes and a close dialogue and cooperation between science, economy, politics and civil society (Golowko et al. 2019; Tiron-Tudor et al. 2018). The European Union has recognized universities as an essential resource for innovation and seeks to support the innovative activities. Higher education is one of the main indicators of global competitiveness and in the future due to globalization and knowledge transfer, modern masters programs should have a multidisciplinary and interdisciplinary approach and be able to answer the demand of the bioeconomy (Carleton-Hug 2010; Pubule et al. 2019).

In the forestry sector, green forest jobs refer to forest based economic activities and therefore are an integral part of a forest-based bioeconomy. With this in mind, there will be significant job opportunities available for forest personnel with appropriate training and expertise in marketing, dispute resolution and public relations (UNECE 2018). The demand for high-skilled workers opportunities is likely to increase and decrease for low-skilled workers. To deal with this demand, an interdisciplinary approach for tertiary education is necessary. Our results show that the students perceive the increased

job opportunities more positive whereas one third is not convinced that they will find a job in the forest-based bioeconomy. An important factor in growing the forest-based bioeconomy is therefore recruiting and training its future workforce and explaining the job opportunities arising from the transition to the bioeconomy.

Development of a knowledge-based bioeconomy requires undoubtedly investment in human capital which, as Rakowska (2011) refers to, is formed basically by formal education. Knowledge-Based Bio-Economy depends on skilled and qualified labour force (Tiron-Tudor et al. 2018). Therefore, university education should respond to these trends and incorporate more courses about the bioeconomy.

The study has few limitations. The perceptions of students were analysed only within one university. This is due to the fact, that in Slovakia only the Technical University in Zvolen provides an education in the area of forestry and wood sciences. The aim of this study was to obtain initial findings on possible differences between students within different study programs. Therefore, the sample was chosen as non-random, ad hoc and was determined by self-selection of the researchers. Some points concerning the conception of the questionnaire could be optimised. A limiting factor could be length of the questionnaire, which some respondents indicated as exhaustive. This could lead to random responses, particularly in the second half of the questionnaire. Our approach, however, enabled the comparisons between multiple study programs and helped to reveal similarities and differences. The results gave us important insights how to innovate and design bioeconomy related courses in the future.

## 5. Conclusions

This paper presented key findings of a study investigating bioeconomy perceptions by students of three bioeconomy related study programs in Slovakia. The research was carried out among students at the Technical university in Zvolen.

More than two-thirds of all respondents have heard about the bioeconomy. The main three sources of information are news, university courses and social media. Only forestry students indicate a greater variance in identified information sources. The perceived contribution of different sectors to the bioeconomy is almost the same for all categories of students, being higher at the European level than at the national level. At the European level, bioenergy, biofuels and forestry sectors were “often” indicated as contributing to bioeconomy, while agriculture sector was seen as “less often” contributing to bioeconomy. Regarding the perceived importance of forestry within bioeconomy, students reported higher importance

of forestry within bioeconomy at European level than at national level. The study program had a greater impact on perceived importance of forests within bioeconomy than the type of study. Forestry students reported higher importance of bioeconomy than the students of other two study programs. Our respondents tend to think that bioeconomy development mostly leads to efficient use of forest products, substitution of fossil-based products with forest-based ones and finding new uses for already existing products. According to interviewed students, forest-based bioeconomy shall be based on combination of new and traditional knowledge and be, predominantly, based on local resources. When asking what bioeconomy should look like, we can see that a bigger impact on respondents’ answers has the study program compared to the type of study. On the contrary, when asking what bioeconomy development will/will not cause, no significant difference occurs between various study programs nor the types of study. The respondents seem to think that development of forest-based bioeconomy will favour sustainable forest management and that it will not lead to increased deforestation, as some people tend to argue. Half of the students don’t have a clear view of their future job position. Only one-fifth of students indicated that the development of forest-based bioeconomy will help them to find a job. Students perceive the increased job opportunities more positive whereas one third is not convinced that they will find a job in the forest-based bioeconomy.

The paper builds on previous international research done by Masiero et al. (2020). It applies on Slovak national level and expands the previous study with different study programs presenting in more detail how Slovak university students perceive bioeconomy and forest-based bioeconomy. Even though, majority of students have heard about bioeconomy, they don’t see bioeconomy development to be crucial for their future job positions. The paper provides information that can be useful in adjusting the study programs to meet the current societal demand, as significant differences were found between respective study programs. This suggests that there is room for improvement regarding the involvement of bioeconomy within respective study curricula.

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## References

- Biber-Freudenberger, L., Basukala, A. K., Bruckner, M., Börner, J., 2018: Sustainability Performance of National Bio-Economies. *Sustainability*, 10:2705.
- Bejinaru, R., Hapenciuc, C. V., Condratov, I., Stanciu, P., 2018: The University Role in Developing the Human Capital for a Sustainable Bioeconomy. *Amfiteatru Economic [e-journal]*, 20:583–598.
- Bugge, M. M., Hansen, T., Klitkou, A., 2016: What is the bioeconomy? A review of the literature. *Sustainability*, 8:691.
- Carleton-Hug, A., Hug, J. W., 2010: Challenges and opportunities for evaluating environmental education programs. *Evaluation and Program Planning*, 33:159–164.
- D'Amato, D. N., Droste, M., Allen, K., Kettunen, J., Lähinen, P., Korhonen, B. D. et al., 2017: Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production* 168:716–734.
- Dreierska, N., 2017: Employment in vs. education for the bioeconomy. In: A. Raupelien (ed.): *Proceedings of the 8th International Scientific Conference Rural Development 2017*, Available at <http://doi.org/10.15544/RD.2017.245>
- Enriquez, J., 1998: Genomics and the World's Economy. *Science*, 281:925–926.
- Glenn, J. C., Florescu, E., 2015: 2015–2016 State of the Future. The Millenium Project, Washington, D. C., USA.
- Golowko, N., Marquardt, K., Budz, S., Foerster-Metz, U. S., 2019: German students' perception of bioeconomy: An exploratory study. *Amfiteatru Economic*, 21: 138–151.
- Hardy, R. W. F., 2002: The bio-based economy. In: J. Janick, A. Whipkey (eds.): *Trends in new crops and new uses*, Alexandria, USA: ASHS Press, p. 11–16.
- Hodge, D., Brukas, V., Giurca, A., 2017: Forests in a bioeconomy: Bridge, boundary or divide? *Scandinavian Journal of Forest Research*, 32:582–587.
- Imbert, E., Ladu, L., Tani, A., Morone, P., 2019: The transition towards a bio-based economy: A comparative study based on social network analysis.
- Kleinschmit, D., Lindstad, B. H., Thorsen, B. J., Toppinen, A., Roos, A., Baardsen, S., 2014: Shades of green: A social scientific view on bioeconomy in the forest sector. *Scandinavian Journal of Forestry*, 29: 402–410.
- Kylkilahti, E., Berghäll, S., Autio, M., Nurminen, J., Toivonen, R., Lähinen, K. et al., 2020: A consumer-driven bioeconomy in housing? Combining consumption style with students' perceptions of the use of wood in multi-storey buildings. *Ambio*, 49:1943–1957.
- Masiero, M. et al., 2020: Bioeconomy perception by future stakeholders: Hearing from European forestry students. *Ambio*, 49:1925–1942.
- McCormick, K., Kautto, N., 2013: The Bioeconomy in Europe: An overview. *Sustainability*, 5:2589–2608.
- Mustalahti, I., 2017: The responsive bioeconomy: The need for inclusion of citizens and environmental capability in the forest based bioeconomy. *Journal of Cleaner Production*, 30: 1–10.
- Navrátilová, L., Výboštok, J., Dobšínská, Z., Šálka, J., Pichlerová, M., Pichler, V., 2020: Assessing the potential of bioeconomy in Slovakia based on public perception of renewable materials in contrast to non-renewable materials. *Ambio*, 49:1912–1924.
- Pätäri, S., Arminen, H., Puumalainen, K., Toppinen, A., Albareda, L., 2017: Student values and perceptions of corporate social responsibility in the forest industry on the road to a bioeconomy. *Forest Policy and Economics*, 85: 201–215.
- Philp, J. C., Krishna, P., 2013: Bio-based production in a Bioeconomy. *Asian Biotechnology and Development Review*, 15: 81–88.
- Philp, J. C., 2015: Balancing the bioeconomy: supporting biofuels and bio-based materials in public policy. *Energy and Environmental Science*, 11:3063–3068.
- Priefer, C., Jörissen, J., Frör, O., 2017: Pathways to Shape the Bioeconomy. *Resources*, 10: 1–23.
- Pubule, J., Kalnbalkite, A., Teirumnieka, E., Blumberga, D., 2019: Evaluation of the Environmental Engineering Study Programme at University. *Environmental and Climate Technologies*, 23:310–324.
- Rakowska, J., 2011: Support for Innovations in Higher Education in Poland under Selected Operational Programmes since 2004. In: Savolainen, M. et al., 2011: *Technology Innovation and Industrial Management 2011*, 28–30 June, Oulu, Finland, p. 1279–1293.
- Ramcilovic-Suominen, S., Pülzl, H., 2018: Sustainable development: A 'selling point' of the emerging EU bioeconomy policy framework? *Journal of Cleaner Production*, 172:4170–4780.
- Richardson, B., 2012: From a fossil-fuel to a biobased economy: The politics of industrial biotechnology. *Environment and Planning C*, 30:282–296.
- Schmid, O., Padel, S., Levidow, L., 2012: The bio-economy concept and knowledge base in a public goods and farmer perspective. *Bio-Based and Applied Economics*, 1:47–63.
- Staffas, L., Gustavsson, M., McCormick, K., 2013: Strategies and policies for the bioeconomy and bio-based economy: An analysis of official national approaches. *Sustainability*, 5:2751–2769.
- Stafford, W., De Lange, W., Nahman, A., Chunilall, V., Lekha, P., Andrew, J. et al., 2020: Forestry biorefineries. *Renewable Energy*, 154:461–475.

- Stern, T., Ranacher, L., Mair, C., Berghäll, S., Lähäinen, K., Forsblom, M. et al., 2018: Perceptions on the Importance of Forest Sector Innovations: Biofuels, Biomaterials, or Niche Products? *Forests*, 9:255.
- Stern, T., Plöhl, U., Spies, R., Schwarzbauer, P., Hesser, F., Ranacher, L., 2018: Understanding Perceptions of the Bioeconomy in Austria – An Explorative Case Study. *Sustainability*, 10:4142.
- Tiron-Tudor, A., Nistor, C. S., Ștefănescu, C. A., 2018: The role of universities in consolidating intellectual capital and generating new knowledge for a sustainable bio-economy. *Amfiteatru Economic Journal*, 20:599–615.
- Other sources*
- European Commission, 2012: Innovating for sustainable growth. A bioeconomy for Europe. Available at <[https://ec.europa.eu/research/bioeconomy/pdf/officialstrategy\\_en.pdf](https://ec.europa.eu/research/bioeconomy/pdf/officialstrategy_en.pdf)
- European Commission, 2018: A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment. Brussels. <https://doi.org/10.2777/478385>. Available at <[https://ec.europa.eu/research/bioeconomy/pdf/ec\\_bioeconomy\\_strategy\\_2018.pdf](https://ec.europa.eu/research/bioeconomy/pdf/ec_bioeconomy_strategy_2018.pdf)
- UNECE (UNECE/FAO Forestry and Timber Section). 2018. Green jobs in the forest sector : Geneva timber and forest discussion paper 71. New York: United Nations, Available at [https://unece.org/fileadmin/DAM/timber/publications/DP71\\_WEB.pdf](https://unece.org/fileadmin/DAM/timber/publications/DP71_WEB.pdf)