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Analysis of forestry employment within the bioeconomy labour market in the Czech Republic

Michaela Perunová[1], Jarmila Zimmermannová[2]*

[1]Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic
[2]Moravian Business College Olomouc, Olomouc, Czech Republic

**Corresponding author: perunova@fld.czu.cz*

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Abstract: Climate change, biodiversity loss, and the increased occurrence of extreme weather events bring new challenges at a global level, not just in forestry. In response to the current situation, modified economic models such as circular economy, green economy, bio-based economy, or bioeconomy, are expected to move society towards a more sustainable future. The main aim of this paper was to evaluate forestry employment and its drivers within the bioeconomy labour market in the Czech Republic. The partial target was to provide a general view of the development of forestry employment within the bioeconomy labour market. The authors applied a mixed methods approach, using literature review, data analysis, correlation analysis, and regression analysis. A decreasing trend of the share of forestry employment in total bioeconomy employment and of the share of bioeconomy employment in the labour market in the Czech Republic was identified. Regarding the drivers of the forestry labour market, based on the results, employment in the forestry sector is positively dependent on wages/salaries and negatively dependent on GDP and forest land.

Keywords: bio-based economy; economic indicators; employment in forestry; regression analysis; Czechia

Global change (Watson et al. 1998) is often perceived as human-induced modifications in climate. Indeed, human activities have undeniably altered the atmosphere, and probably the climate as well. Non-human climate changes tend to be slower and less destructive than anthropogenic climate change. At the same time, most of the world's forests have also been extensively modified by human use of the land. Global climate change is predicted to bring a different climatic future to the world's major forest regions. The study (Kim et al. 2017) represents the impact of climate change on global forests and based on climate system modelling, concludes that climate mitigation can bring benefits as well as costs. Based on Hansen et al. (2001), consideration of climate, land use, and biological diversity is a key to understanding the forest response to global change.

The forest bioeconomy plays a significant role in capturing carbon in sustainably managed forest ecosystems and their products (Green Growth Knowledge Platform 2011). The forest bioeconomy can contribute to the Paris Agreement's aim to achieve a balance between anthropogenic greenhouse gas emissions by sources, and removals by sinks (UNFCCC 2015), by increasing the carbon stocked in forest land and in harvested wood products. A sustainable forest bioeconomy plays an essential role in the carbon cycle and provides essential environmental and social values. For the for-

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est bioeconomy, the most important challenges are to find innovative approaches to managing forest resources in a way that simultaneously increases wood and non-wood production (Marchetti et al. 2014).

Climate change, biodiversity loss and the increased occurrence of extreme weather events bring new challenges at a global level, not just in forestry. At the global level, the European Union has now taken the lead and critical objectives have been identified, such as ensuring the long-term competitiveness of European industry as well as climate neutrality by 2050. We can speak about this issue as highly topical and with a global impact. The Paris Agreement (United Nations 2015b), the European Climate Law (EU 2018/1999), the European Green Deal (European Commission 2019), and other environmental visions are being followed up by the latest Fit for 55 packages. A legislation revision aims to reduce net greenhouse gas emissions by at least 55% by 2030 (European Commission 2021), increase the adaptability of forests and the natural restoration of forests, as well as financially support sustainable forest management across EU countries. The New EU Forest Strategy for 2030 (European Commission 2021) can be considered as part of the package.

The sustainable economy policy package is complemented by the EU Bioeconomy Strategy (European Commission 2018), and the New EU Circular Economy Action Plan (European Commission 2020). Further, the US Sustainable Development Goals (United Nations 2015a), and the European Forests for biodiversity, climate change mitigation and adaptation (Science for Environment Policy 2021) have already been developed.

In the Czech Republic, the first strategic framework for the circular economy (Ministry of Environment 2021) was approved by the end of 2021. A significant area of interest of the Circular Czech Republic 2040 (Ministry of Environment 2021) is the development of the Czech bioeconomy, which should create new jobs across the European country.

Globally, pressure is increasing on the demand side for food, feed, biomaterials, and bioenergy resources, putting more pressure on natural resources. The transformation from a linear economic system to a more sustainable one has begun. We can observe modified economic models such as circular economy, green economy, bio-based economy, or bioeconomy. The circular bioeconomy has a significant impact on sustainable development. The bioeconomy (European Commission 2018) covers all sectors and systems that rely on biological resources, their functions, and principles. It interlinks land and marine ecosystems, all primary production sectors and all sectors using biological resources to produce food, feed, bio-based products, energy, and services.

Based on scientific literature (Ronzon et al. 2015), the national bioeconomies of the EU states can be divided into four groups of countries such as agricultural bioeconomies (Slovenia, Greece, Romania), agro-food industry and bio-based chemical industries (Italy, France, Germany), forestry bioeconomies (Finland, Sweden, Estonia), and non-specialised bioeconomies (Czech Republic, Slovakia, Hungary). Ronzon et al. (2020) defined the following subsectors of bioeconomy: agriculture, forestry, fishing, manufacture of food products, beverage and tobacco, manufacture of bio-based textile, manufacture of wood and wood products, manufacture of paper, manufacture of bio-based chemicals, manufacture of bio-based pharmaceuticals, manufacture of bioplastics, manufacture of liquid biofuels and the production of bioelectricity. Forestry represents the key sector of the bioeconomy.

In scientific studies focusing on bioeconomy issues, there is still a lack in this field. The most easily available scientific studies are national case studies. However, the socio-economic effects of the bioeconomy, such as employment, turnover, and GDP, have not been very well researched. For example, Carus (2012) provided an overview of the quantitative dimensions of the European bioeconomy and displayed the first-ever collection and analysis of bioeconomy data across the EU-27 Member States. The calculation of effects includes indicators such as the number of enterprises, employed persons, and value added. Subsequently, the high employment values in the individual bioeconomy sectors are caused by natural and geographical conditions in each country (Drejerska 2017). According to a study performed by Hetemäki and Hurmekoski (2016), at the European level is still a lack of studies that develop an area such as the forest labour market. Regarding the Jonsson et al. (2021) support of logging wood, the production of wood products, and sectors that use the by-product as a feedstock seem to be an opportunity to boost bioeconomy employment. Another study (Efken et al. 2012) assessed the macroeconomic

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impact of the bioeconomy in Germany and analysed four indicators such as the number of companies, employment, turnover, and gross value added. The study (CEPI 2012) refers to direct and indirect value added and employment in the European pulp, paper, and paperboard industry. On the contrary, Dammer et al. (2017) showed the new estimation of employment and turnover figures of the European bioeconomy. Regarding the multiplying effects of the bioeconomy (Mainar-Causapé et al. 2017), each EUR million spent on bioeconomy products newly generates 12 employed persons in the bioeconomy sectors, especially in agriculture, in the food and paper industry. The highest direct employment effects are represented by expenditure on forestry and agricultural products.

Regarding the studies focusing on the Czech Republic (Purwestri et al. 2020), opportunities for sustainable forest biomass and high-added value products opened in the forestry market. Based on the study performed by Hájek et al. (2021), health conditions in sectors such as forestry, agriculture, and food industries seem to be necessary for the development of a circular economy at the local level. Zimmermannová and Perunová (2022) evaluated employment and its trends in selected sectors of the bioeconomy as the main drivers of the labour market and identified GDP, wage, and subsidy development.

Based on the literature review, we highlight a lack of studies that would address the topic of forestry employment within the bioeconomy labour market in the Czech Republic. The analysis presented in this article will try to fill this gap.

MATERIAL AND METHODS

Material. To achieve the aim, various data sources were used, both from scientific databases and official institutional online sources. The essential data sources are represented by the data published in scientific studies (scientific databases Web of Science, Scopus, Research Gate, etc.), as well as the official websites of the European Union. For the period 2000–2020, detailed data connected with bioeconomy, bioeconomy sectors, features of such sectors, and forestry were used from the Eurostat database (Eurostat 2022), the Czech Statistical Office (CZSO 2022) and the Data-Modelling platform of agro-economic research (European Comission 2021). Table 1 shows the overview of all data/variables used for correlation and regression analyses presented in this paper, including abbreviations, units, and roles of the variables.

The key dependent variable is "employment in forestry". The "employment" is a suitable indicator characterising the labour market (Blais 1986; Samuelson, Nordhaus 2009). Regarding independent variables, they were chosen based on their expected influence on employment in forestry. Based on the labour market theory (Samuelson, Nordhaus 2009), wages and salaries influence employment and unemployment. Simultaneously, an increase in GDP represents transformation of the economy, increases in digitisation, and the creation of new jobs (Toth et al. 2019). It can cause the movement of employed people from forestry and other traditional sectors to other, up-to-date sectors. Environmental investments are necessary for transition to cleaner technologies (Toth et al. 2019). Together with subsidies (Blais 1986), they can support environmentally important sectors of the national economy, such as forestry. Forest land is an important indicator, wood is a renewable natural resource, and we can expect an increase in demand for this energy source (Hájek et al. 2021). Time represents the control variable.

The following Table 2 summarizes the parameters of variables described in Table 1. For each variable, minimum and maximum values, standard deviation, and the median are indicated.

Methods. The main aim of this paper is to evaluate forestry employment and its drivers within the bioeconomy labour market in the Czech Republic.

Table 1. List of variables

Variable	Abbreviation	Units	Role
Employment in forestry	*FORE*	thousand persons	dependent
Gross domestic product at market prices	*GDP*	current prices, million EUR	independent
Wages and salaries	*WAGE*		
Subsidies	*SUBS*		
Environmental investments	*INV*		
Forest land	*FORL*	ha	
Time	*TIME*	years	

Source: Authors' own elaboration

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Table 2. Overview of the data statistics

Variable	Minimum	Maximum	Standard deviation	Median
FORE	21	37.66	5.477	26.83
GDP	67 032.5	225 568.7	46 186.96	157 920.8
WAGE	19 989.3	77 380.2	16 662.85	50 328.5
SUBS	1 470.7	7 975.8	1 833.277	3 857.5
INV	596.7	1 604.4	250.520	939.64
FORL	2 637 289	2 677 329	12 458.08	2 657 376
TIME	2000	2020	–	2010

FORE – employment in forestry; *GDP* – gross domestic product at market prices; *WAGE* – wages and salaries; *SUBS* – subsidies; *INV* – environmental investments; *FORL* – forest land; *TIME* – time
Source: Authors, based on Eurostat (2022) and CZSO (2022)

Based on the above literature review and linking up with the paper objectives, the following research questions should be answered:

RQ1: Can we observe a decreasing trend of employment in the forestry sector within the bioeconomy labour market in the Czech Republic?

RQ2: What are the main drivers of employment in the forestry sector in the Czech Republic?

For the achievement of the main aim of our research and to answer the research questions, we used the following methods: literature review, data analysis, correlation analysis, and regression analysis.

To answer RQ1, the following methodological approach was used: based on the set target, the statistical data were collected, and the sectoral approach was applied. Regarding the statistical data, the main data sources for employment in the bioeconomy reported in the figures are Eurostat, the Data-Modelling platform of resource economics, and the Czech Statistical Office.

Focusing on the sectoral comparative analysis, changes in the structure of the employment in particular bioeconomy subsectors were analysed and compared. The key methodology was performed by the Data-Modelling platform of agro-economic research (European Commission 2021).

Considering the sectoral approach, employment data were listed by the NACE rev. 2 Classification. Agriculture, forestry, fishing, the manufacturing of food, beverage, tobacco, and paper were used as pure bioeconomy sectors. Other sectors, such as the manufacture of textiles, wearing apparel, leather, wood products, furniture, chemicals, pharmaceuticals, plastics and rubber, and electricity production, represent hybrid segments with a bio-based share of employment.

To answer RQ2, the following methodological approach was used: correlation analysis (Pearson's correlation coefficient) and regression analysis were carried out based on the above-described data (Tables 1 and 2). The authors use the linear regression models. The key one is the regression model MOD1 which calculates the relation between employment in forestry and all other variables.

The general regression equation of MOD1 is as follows [Equation (1)]:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \\ + \beta 5X5 + \beta 6X6 + u \quad (1)$$

where:

Y – employment in the forestry sector (FORE);
β0–β6 – regression coefficients that reflect the impact of the independent variable on the dependent variable;
u – random element of the model;
$X1$ – GDP (*GDP*);
$X2$ – wage (*WAGE*);
$X3$ – subsidies (*SUBS*);
$X4$ – environmental investments (*INV*);
$X5$ – forest land (*FORL*);
$X6$ – time (*TIME*).

Regression model MOD2 includes all variables like MOD1, except for *TIME*. MOD3 represents the more focused and statistically significant model. MOD2 and MOD3 are described in more detail in Results.

RESULTS

Employment in the forestry sector within the bioeconomy labour market. The changes in the structure in particular bioeconomy subsectors in the Czech

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Republic in 2010–2019 are presented in Figure 1; several categories were used, namely agriculture; food, beverage, and tobacco; forestry; wood products and furniture; paper; fishing and aquaculture; bio-based textiles; bio-based chemicals, pharmaceuticals, plastics, and rubber. The highest share of bioeconomy employment was represented each year by traditional economy sectors, such as agriculture; food, beverage, tobacco; wood products and furniture. Based on the results, about two-thirds of bioeconomy employment in the Czech Republic comes from agriculture and food, beverage, and tobacco.

Table 3 shows that the share of the bioeconomy sectors in the labour market in the reported period was approximately 7%–8%. The highest share was observed in 2012 (7.94%) and the lowest share in 2019 (7.31%). We can observe a declining trend. Consequently, the share of forestry in the bioeconomy labour market was around 5%–6%. The highest share of forestry in the bioeconomy labour market in the Czech Republic was observed in 2011 (6.98%). In contrast, its lowest value was in 2019 (5.42%). Based on the figures, a declining trend can be observed in the share of forestry in the bioeconomy labour market in the Czech Republic in the period 2010–2019.

Correlation analysis. Table 4 shows the results of the correlation analysis. The variables are described in more detail in Tables 1 and 2.

Focusing on employment in forestry (*FORE*), we can observe negative correlations with all other selected variables (*GDP*, *WAGE*, *SUBS*, *INV*, *FORL*, and *TIME*). To identify the drivers of the forestry labour market, we will use linear regression analysis.

Regression analysis. Table 5 presents models MOD1, MOD2, and MOD3 with forestry employment (*FORE*) as a dependent variable.

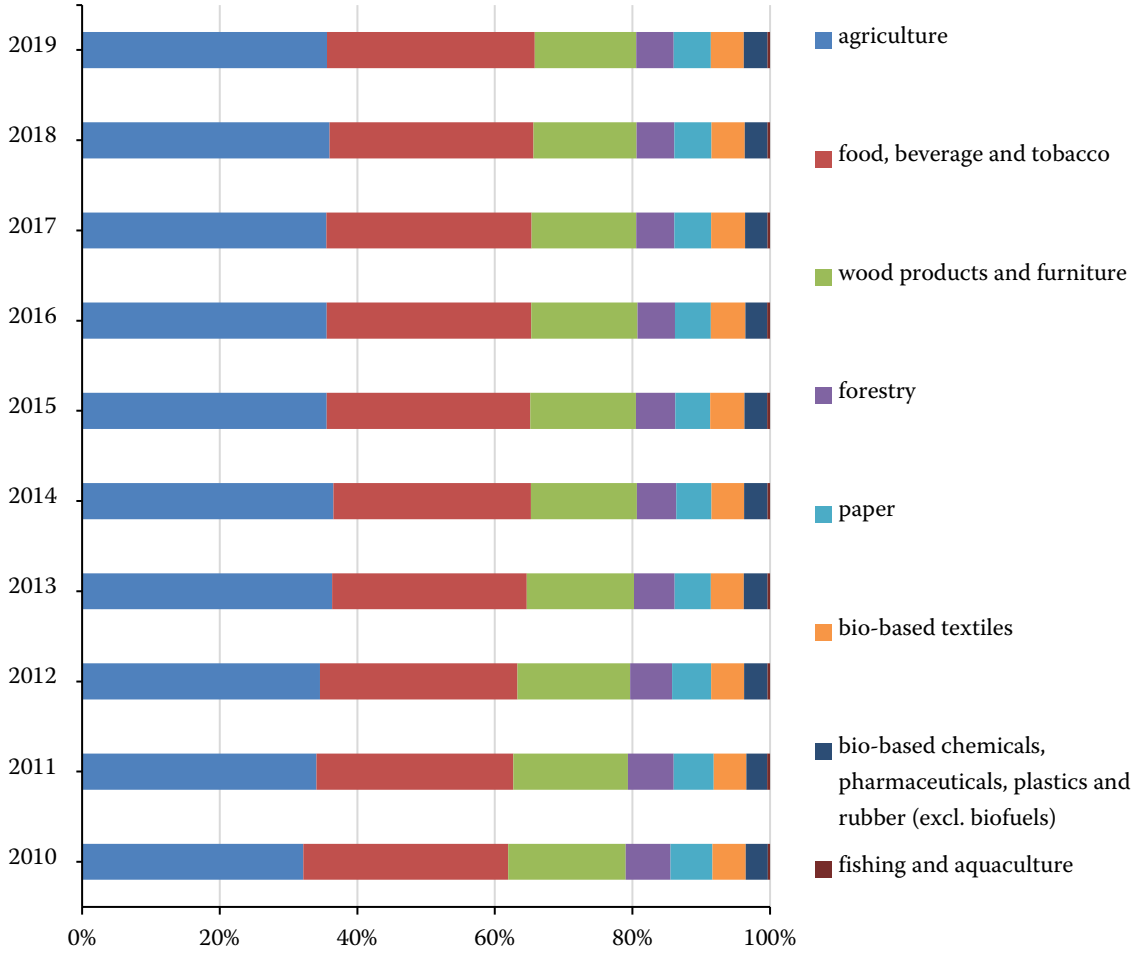

Figure 1. Changes in the structure of the bioeconomy employment in the Czech Republic in 2010–2019

Source: Authors' own processing, based on Eurostat (2022) and European Commission

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Table 3. Forestry in the bioeconomy labour market (%)

Year	Employed persons in total (thousand persons)	Employed persons in the bioeconomy (thousand persons)	Share of the bioeconomy sectors (%)	Employed persons in forestry (thousand persons)	Share of forestry in the bioeconomy sectors (%)
2010	4 885.200	385.535	7.89	25.96	6.73
2011	4 872.400	384.328	7.89	26.83	6.98
2012	4 890.100	388.348	7.94	24.64	6.34
2013	4 937.100	385.620	7.81	23.49	6.09
2014	4 974.300	384.186	7.72	22.61	5.89
2015	5 041.900	385.228	7.64	22.62	5.87
2016	5 138.600	383.281	7.46	21.50	5.61
2017	5 221.600	386.146	7.40	21.87	5.66
2018	5 293.800	395.281	7.47	21.82	5.52
2019	5 303.100	387.510	7.31	21.00	5.42

Source: Czech Statistical Office (2022), European Commission (2021), own processing

Table 4. Correlation analysis

Variable	*FORE*	*GDP*	*WAGE*	*SUBS*	*INV*	*FORL*	*TIME*
FORE	1	–	–	–	–	–	–
GDP	–0.943	1	–	–	–	–	–
WAGE	–0.933	0.996	1	–	–	–	–
SUBS	–0.944	0.939	0.949	1	–	–	–
INV	–0.805	0.728	0.723	0.790	1	–	–
FORL	–0.982	0.962	0.963	0.972	0.826	1	–
TIME	–0.980	0.968	0.969	0.973	0.823	0.999	1

FORE – employment in forestry; *GDP* – gross domestic product at market prices; *WAGE* – wages and salaries; *SUBS* – subsidies; *INV* – environmental investments; *FORL* – forest land; *TIME* – time

Source: Authors' own elaboration

Table 5. Regression analysis

Parameter	MOD1		MOD2		MOD3	
	sig.	coef.	sig.	coef.	sig.	coef.
*X*1 (*GDP*)	0.00542	–0.00017	0.004034596	–0.00017	0.00320889	–0.00016
*X*2 (*WAGE*)	0.00320	0.00055	0.002104713	0.000556	0.001759668	0.00047
*X*3 (*SUBS*)	0.52894	–0.00033	0.547242726	–0.0003	–	–
*X*4 (*INV*)	0.25074	0.00007	0.191729396	8.06E–05	–	–
*X*5 (*FORL*)	0.15738	–0.00064	6.99925E–05	–0.00052	1.03867E–07	–0.00048
*X*6 (*TIME*)	0.78291	0.27617	–	–	–	–
Constant	0.22402	1 159.86084	0.00005	1 405.418	0.00000	1 315.08900
Observ.	21	–	21	–	21	–
R^2	0.99167	–	0.99163	–	0.990408	–
Signif.	0.00000	–	0.00000	–	0.00000	–
DW	2.46538	–	2.374555	–	2.191986	–

MOD1–3 – model 1–3; *GDP* – gross domestic product at market prices; *WAGE* – wages and salaries; *SUBS* – subsidies; *INV* – environmental investments; *FORL* – forest land; *TIME* – time; *DW* – Durbin-Watson test

Source: Authors' own elaboration

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MOD 1 consists of all independent variables (*GDP*, *WAGE*, *SUBS*, *INV*, *FORL*, and *TIME*). The whole model is statistically significant, but not all selected variables are statistically significant.

MOD2 represents the same variables as MOD1, excluding *TIME* as the variable with the statistically lowest significance.

MOD3 represents variables with $P < 0.01$ statistical significance from MOD1 and MOD2 (*GDP*, *WAGE* and *FORL*). This last model MOD3 is the statistically significant model – all variables are statistically significant and the whole model is also statistically significant. *DW* was calculated for this model, and it is also acceptable (2.19). We can write the following regression equation:

$$Y = 1\,315.08900 - 0.00016X1 + 0.00047X2 - - 0.00048X5 \quad (2)$$

Employment in the *FORE* sector is positively dependent on wages/salaries and negatively dependent on *GDP* and forest land.

DISCUSSION

The Czech Republic was identified in Ronzon's study (Ronzon et al. 2015) as a non-specialised bioeconomy, together with other Visegrad countries, namely Slovakia and Hungary. Considering the structure of the bioeconomy labour market in the Czech Republic in the observed period, we can confirm such a result. Based on the above-presented analysis, about two-thirds of bioeconomy employment come from traditional sectors of the national economy, such as (1) agriculture, and (2) food, beverage, and tobacco.

Regarding forestry, the share of forestry employment in the bioeconomy employment decreased in the observed period, it was 5.42% in 2019. This result is similar to the study performed by Toth et al. (2019). On the other hand, due to the Green Deal and new environmental policy, we can expect an increase in the number of new jobs in forestry. According to Philippidis et al. (2014), the forestry, fishing, and wood sectors represent segments with the most significant impact on the creation of new jobs in the European bioeconomy. Regarding Jonsson et al. (2021), support of logging wood, the production of wood products, and sectors that use the by-product as a feedstock seem to be an opportunity to boost bioeconomy employment.

Focusing on the drivers of employment in the forestry sector in the Czech Republic, there is a positive relationship between employment and wages/salaries, and a negative relationship between GDP and forest land. Social indicator (employment) as a dependent variable was used in many studies, such as Parisi and Ronzon (2016), Lier et al. (2018), Berkel and Delahaye (2019), Bracco et al. (2019), Kardung et al. (2019), Capasso and Kiltkou (2020), Alviar et al. (2021), and Ronzon et al. (2022). For example, Ronzon et al. (2022) concluded that modernisation, innovation, and employment reallocation are factors influencing changes in the development of bioeconomy employment. Some Northern and Western EU Member States are working on bioeconomy transformation through modernisation and structural changes in the national economies (Ronzon et al. 2021). However, Eastern and Central EU Member States are still in the early stages of a bioeconomy transition. Based on the last CBE JU policy (CBE JU 2022), a total of EUR 120 million will be dedicated to advancing competitive circular bio-based industries in Europe, including forestry. We can expect an increase in new jobs connected with renewable energy sources and/or bio-based products.

Regarding the methodology and methodological approach, correlation and regression analyses provide interesting and valuable results. On the other hand, the lack of quality primary and secondary data sources in suitable structure in forestry (Robert et al. 2020) appears to be a limiting factor for properly evaluating the forestry labour market. Simultaneously, there is a crucial need for innovative methods of measuring the development of the bioeconomy sectors (Sanz-Hernández et al. 2019), including forestry.

CONCLUSION

Forests are under tremendous pressure from global change. To tackle global challenges, it seems to be important to improve and innovate the way we produce and consume food, products, or materials. It requires investments, innovation, strategies as well as systemic changes across different economic subsectors, not just in the forest bioeconomy. Interdisciplinary science that integrates the knowledge of many interacting climate services of forests with the impacts of global change is necessary to identify and understand as yet unexplored

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feedbacks in the Earth system and the potential of forests to mitigate climate change. Concerning the forest bioeconomy, wood production can increase as long as we manage our forests sustainably. Then a sustainable forestry bioeconomy provides essential environmental and social values. From the environmental point of view, a sustainable forest bioeconomy can provide negative emissions or carbon sinks. Subsequently, employment can be considered the leading social identifier of the forest bioeconomy. The main aim of this paper was to evaluate forestry employment and its drivers within the bioeconomy labour market in the Czech Republic. The partial target was to provide a general view of the development of forestry employment within the bioeconomy labour market. Focusing on our research questions RQ1 and RQ2, we can conclude that there is a decreasing trend of the share of forestry employment in total bioeconomy employment in the Czech Republic with the share of forestry employment in the bioeconomy labour market being around 5%–6%. Employment in the forestry sector is positively dependent on wages/salaries and negatively dependent on GDP and forest land.

Monitoring and evaluating socio-economic indicators provide an essential insight into the size, impact, and development of the forestry bioeconomy. Based on the results, a significant knowledge gap still exists in the forestry bioeconomy labour market at both European and national levels. This research fulfilled the picture of the bioeconomy employment in the Czech Republic, especially in forestry.

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