

RESOURCE EFFICIENCY AND RAW MATERIAL USE IN WOOD- WORKING INDUSTRIES IN EASTERN EUROPE: CHALLENGES AND OP- PORTUNITIES FOR SUSTAINABLE PRODUCTION

The paper presents the results of research performed for forest sectors. The present researching is based on the comparison of the forest sectors three ENP countries (Ukraine, Moldova and Georgia) in the one hand and Polish forest sector from the other hand. In the process of the researching was determined and analyzed the main economic parameters of the forest sectors, the forest resources of the forest sectors for mentioned above countries, the contribution of these forest sectors to national GDP. As a result it has been identified the following challenges of the sustainable production for woodworking industry in Eastern Europe: economic power of the forest sectors in Eastern Europe shifted towards forestry; forest sectors in Eastern Europe differ by very poor productivity; there are very few enterprises in forest sectors of ENP countries comparing with EU countries because of complicity of doing business here; forest sectors of ENP countries produce much less products in in turnover terms; forest sector's share in ENP countries does not exceed level of 2 % from national GDP and there is tendency to constant decreasing of this share.

Keywords: forest sector; turnover; number of enterprises; number of employees; ENP countries; forest resources; main challenges and opportunities; sustainable development.

Introduction. Wood is remarkable material since there are at least four extraordinary properties (so-called 4-R properties) of wood as a unique material [1-14]:

- wood is renewable material;
- wood is reused material;
- wood is recycled material;
- wood is refined material.

Some branches which have deal with wood it is possible to unite into forest sector which we can consider as a very important sector because it offers a simple way to reduce the CO₂ emissions that are the main cause of Climate Change, through:

- the carbon sink effect of the forests;
- the carbon storage effect of wood products;
- substitution of carbon-intensive materials.

ENP eastern countries hold considerable, yet less developed forest resources with a comparatively average lower land use pressure than in Western Europe (in total 15 million ha). A constantly growing demand for wood raw materials in European markets (2010: 0.8 billion m³, 2020: 1,1 billion m³, increase by +38%) leads to higher raw material imports and growing pressure on forests holding substantial, unexploited wood resources in neighboring Eastern Europe. The main challenge here is to support the development of sustainable management regimes of the abundant resource.

The wood-based industries, emerging anew in post-socialist economies, play a key role in this context, as they could develop an even stronger impact on regional production, employment and value adding -on the basis of regional natural resources. As such, the ENP region is currently gaining in importance as a raw material supplier with many downsides of a strategic new market for foreign investors (e.g. illegal logging and timber trade, offshoring of production, cut-throat competition, corruption, etc.).

Wood manufacturing is shaped by a large number of SMEs, mostly lacking proper organizational structures and staff to implement efficiency measures. Improvements are however urgent, because this SME-dominated sector consumes huge amounts of

raw material per employee, and in total (ENP eastern countries' round wood consumption: 10 million m³/y; total forest products: 20 million m³/y).

The forestry and woodworking sector in ENP eastern countries faces major societal challenges (the unsustainable use of forest resources and wood materials), but shows decisive opportunities for improvement of the current state (increase of raw material efficiency and technological upgrading). And therefore it is very important in our point of view to identify the main challenges of the sustainable production for woodworking industry in Eastern Europe.

Objective. The main objectives of the present research were the following:

- to determine and to analyze the main economic parameters of the forest sectors for such countries as Ukraine, Moldova, Georgia and Poland;
- to determine and to analyze the forest resources of the forest sectors for mentioned above countries;
- to determine and to analyze the contribution of these forest sectors to national GDP.

Methods. For researching we use definition „forest sector”. In such structure we decided to include four branches (subindustries) which have deal mostly with solid wood which we are considering as material that differs by very important economic, social and ecological mining: forestry, woodworking industry, furniture manufacturing, carpentry and joinery. The view of one large forest sector was put forward by the European Union to promote a common strategy for sustainable development of one of its largest industrial sectors. The main idea in this connection was nominally to unite the main industries or subindustries in one sector regarding decisive significance such resource as “forest” to derive valuable conclusions/ideas/measures for guaranteeing of sustainable development.

The present researching is based on the comparison of the forest sectors three ENP countries (Ukraine, Moldova and Georgia) in the one hand and Polish forest sector from the other hand. This “country choice” was motivated by the following reasons: Ukraine, Moldova and Georgia are ones of the most important in economic terms representatives of Eastern Partnership; Ukraine, Moldova and Georgia declare their commitments to the European way of development and it is important to evaluate their “forest possibilities” at the beginning of this way; Poland is a country which passed the way from country of socialist camp to the one of the EU leader; there are a lot of similarities between forest sectors of Ukraine and Poland; there are some similarities between forest sectors of Moldova and Georgia.

As the main parameters for any forest sector identifying we used the following:

- overall turnover; number of enterprises;
- number of employees.

The present researching is conducted for the five-year's time period beginning from 2008 and finishing 2012 but the main comparing are made for 2012.

The forest recourse we characterized by the following indexes: square of the forest land, overall timber stock, forest land percentage, procurement of merchantable wood and others value of which it is possible to derive from mentioned above with help of some additional ones.

Results and discussion. The obtained results in regards to three main parameters of the national forest sectors (turnover, number of enterprises and number of employees) are presented in Table 1. In order to analyze effectiveness of the forest resource for the different national sectors it has been used ten main indexes presented in Table 2. Additionally it has been determined these forest sector's shares to the overall turnover, to the overall number of employees and to the overall GDP that are presented in Tab. 3.

Table 1. Main parameters of the national forest sectors in 2012

Main parameters of the national forest sector	Name of the “forest” subindustry				Totally for national forest sector
	Forestry (02)	Wood-working industry (20)	Furniture manufacturing (36.1)	Carpentry (45.22) + Joinery (45.42)	
Ukraine					
Turnover, bil. UAH	6,1	10,3	7,2	0,82	24,42
Number of enterprises, units	991	3128	1548	601	6268
Number of employees, ths. persons	66,2	43,1	38,5	3,91	151,71
Moldova					
Turnover, bil. MDL	0,215	0,223	0,69	0,527	1,655
Number of enterprises, units	27	302	370	77	776
Number of employees, ths. persons	3,75	1,4	2,7	0,95	8,8
Georgia					
Turnover, bil. EUR	6,91	43,59	42,76	-	93,26
Number of enterprises, units	78	213	387	-	678
Number of employees, ths. persons	4,91	1,867	2,650	-	5,008
Poland					
Turnover, bil. PLN	9,32	29,56	28,79	-	67,67
Number of enterprises, units	19190	35597	27047	-	82194
Number of employees, ths. persons	31,1	101,5	138,6	-	271,2

Table 2. Some indexes which determine forest resources of the national forest sectors (2012)

Index's name	Index's value			
	Ukraine	Moldova	Georgia	Poland
Square of the forest land, mil Ha	10,80	0,37	2,82	9,40
Overall timber stock, bil m ³	1,80	0,05	0,45	2,40
Forest land percentage, %	15,70	12,70	40,50	30,00
Timber stock per enterprise, ths m ³ /unit	287,17	57,99	670,35	29,20
Turnover per timber stock, EUR/m ³	1,31	2,29	0,21	6,88
Turnover per procurement of merchantable wood, EUR/m ³	134,30	210,11	208,40	445,86
Procurement of merchantable wood, ths m ³	17506,7	490,0	447,5	37045,0
Timber stock per inhabitant, m ³ /person	39,09	12,50	103,30	62,83
Population, mil persons	46,05	3,60	4,40	38,20
Square of the forest land per inhabitant, Ha/person	0,23	0,10	0,64	0,25

Table 3. Some parameters of the relative ranking for the national forest sectors (2012)

Index's name	Index's value			
	Ukraine	Moldova	Georgia	Poland
Forest sector's share to the overall turnover, %	1,8	3,47	1,4	5,0
Forest sector's share to the overall number of employees, %	6,6	12,1	1,0	9,0
Rank by turnover share	9	10	10	8
Forest sector's share to the overall GDP, %	1,68	1,88	0,90	1,60

Structure of the forest sectors in turnover, number of enterprises and number of employees terms for such countries as Ukraine, Moldova, Georgia and Poland are presented in Fig.1...Fig.3. As shown in these figures, structure of the forest sectors is determined by share of different branches within the framework of these forest sectors. Among these subindustries we used the following ones: forestry, woodworking industry, furniture manufacturing and carpentry (Fig.1...Fig.3).

Analyzing structure of the forest sectors in turnover terms it is possible to point out that in Ukraine we have the largest share of the forestry in overall forest sector and it makes up 25 % (Fig. 1). As shown in Fig.3 in Ukraine the largest number of employees works in forestry. In our opinion two last facts allow to conclude that in Ukraine we can observe “too much attention” to forestry comparing with other subindustries and other countries. In the same time in Poland and in Georgia such very important branches which provide secondary timber treatment and therefore can provide more value added as woodworking industry and furniture manufacturing make up together approximately 90 % (Fig.1...Fig.3). Comparing these shares with Ukrainian and Moldavian respective parameters we can observe much less such shares. For instance, taking into account number of employees terms (Fig. 2), it turns out that summing share of number of employees in woodworking industry and furniture manufacturing in Ukraine makes up only 54 % and in Moldova respective index is equal to 47%.

As a result, in our point of view, forest sectors of Eastern Neighborhood Partnership need substantial improving since we can consider forestry in forest sector as raw material branch, some extract branch saying about industrial capacities (in fact, forestry has some other very important tasks as planting and saving of the timber stock using sustainable management rules) and therefore we should replace industrial development to the site of deeper treatment, towards development and growing of the secondary processing: woodworking industry, furniture manufacturing and carpentry. These changes will allow to increase economical effectiveness and number of employees. Using data from Table 1 it can determine so-called average enterprises for forest sectors of the different countries. In our opinion it is interesting to compare such indexes as average turnover for forest sector's enterprise (Fig. 4), average turnover per employee (Fig. 5) and average number of employees (Fig. 6). As shown in the Fig. 4, in 2012 the largest turnover per forest sector's enterprise we had in Ukraine while for other countries from our researching list average turnover approximately is two times less than in Ukraine.

As we can see in Fig. 5 average turnover per employee in Poland is approximately three times more than in three countries of Eastern Neighborhood Partnership but in Ukraine there is the largest number of employees for average forest sector's enterprise (Fig. 6). Analyzing these three figures we can conclude that the most effective employee works in Polish forest sector since in average such employee make production in three times more (in turnover terms) than in other countries (Fig. 5). It is very interesting that the most effective enterprise (in turnover terms) of the forest sector we have no in Poland as well since according our data the Ukrainian enterprise differs by the largest turnover (Fig. 4). And what is more, average Ukrainian enterprise has more employees than other forest sector's enterprises in Moldova, Georgia and Poland (Fig. 6). Of course there is some contradiction – the most economically powerful employee we have in Poland but the most powerful enterprise – in Ukraine. We can suggest some logical explanation for this phenomenon – we can assume that in Eastern Neighborhood Partnership countries and particularly in Ukraine there is considerable underestimation regarding number of enterprises and as consequence number of employees in its forest sector.

There are some reasons of such underestimation. Among them we can determine existing shadow sector in ENP countries, concealment of real number of employees and enterprises with purpose of real taxation avoiding. In order to draw some very important conclusions and to elaborate some recommendations for forest sectors improving we in the process of our researching made comparison for forest sectors of four countries determining four main parameters: turnover, number of enterprises and number of employees. It turned out that the most powerful forest sector we can assume the Polish forest sector by main parameters mentioned above. In 2012 turnover of the Polish forest sector made up 16,5 bil EUR while in Ukraine this index made up 2,35 bil EUR and respectively for Moldova and Georgia we have the same index – 0,1 bil EUR. There is similar picture in respect to number of employees (Table 1). In today's difficult social and economic conditions in Europe Union in regard to crisis manifesta-

tions we tend to consider number of employees as one of the most important index which depend from many different factors including number of enterprises.

As shown in Fig. 7 there is a huge difference between number of enterprises in Polish forest sector in the one hand and other forest sectors in the second one. In order to lead this data to a common denominator we should eliminate the influence of such factors as number of inhabitants and timber stock per inhabitant. In other words it is necessary to take into account in this case certain country's dimensions and existence of the forest resources. We can still observe a very large difference regarding number of enterprises even using such specific indicator as number of enterprises per million of inhabitants (Fig. 8). This difference (between Polish and other countries) approximately makes up more than a tenfold advantage in comparison to Ukraine, Moldova and Georgia. And we cannot explain this fact by the difference of forest resources availability since as shown in Fig. 9 Georgia has the largest index of timber stock per inhabitant. We tend to think that beside such problem as large share of the shadow sector within ENP countries' forest sectors there is some other one and maybe more important - complexity of doing business in the forest sectors of ENP countries.

In our opinion there are a lot of different conditions which complicate process of the enterprises creation in forest sectors such as availability of the timber in these countries, non-effectiveness of the state ownership in different areas of the forest sector, procedure of the timber resources sale and some others.

As shown in Fig. 10 and Fig. 11, Poland produces more products in its forest sector in turnover terms from 1 m³ of procurement merchantable wood and from 1 m³ of overall timber stock as well. In this regard we can consider Polish forest sector as the more productive in comparison to forest sectors of Ukraine, Moldova and Georgia.

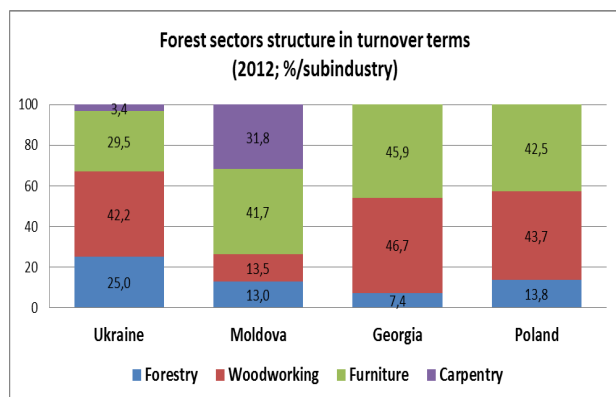


Fig. 1. Shares of the forest sector's subindustries for different countries in turnover terms

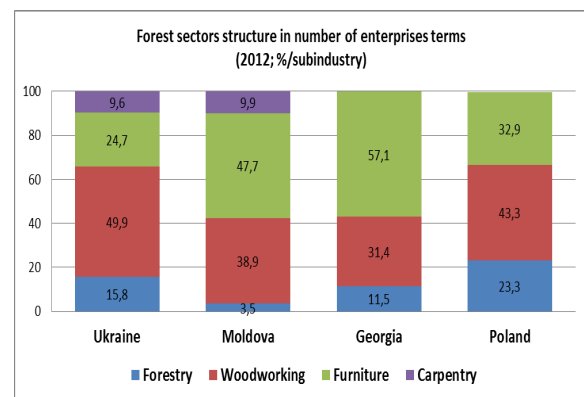


Fig. 2. Shares of the forest sector's subindustries for different countries in number of enterprises terms

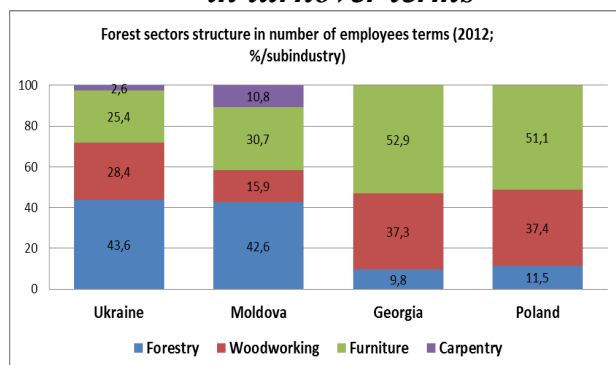


Fig. 3. Shares of the forest sector's subindustries for different countries in number of employees terms

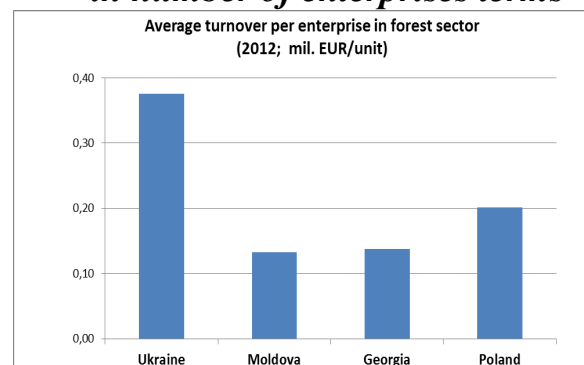


Fig. 4. Average turnover for forest sector's enterprise in different countries

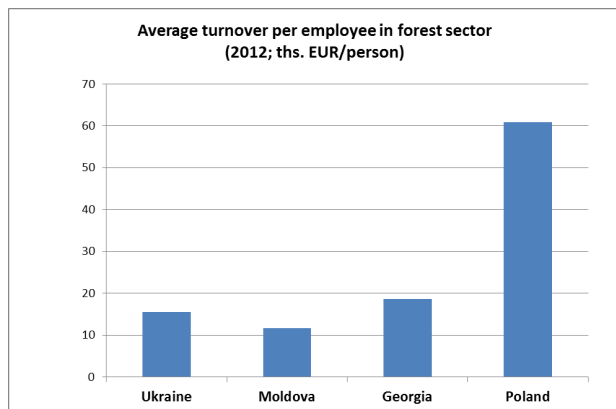


Fig. 5. Average turnover per employee of the forest sector's enterprise in different countries

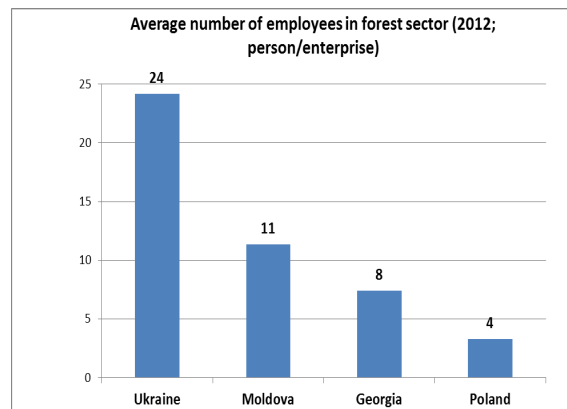


Fig. 6. Average number of employees of the forest sector's enterprise in different countries

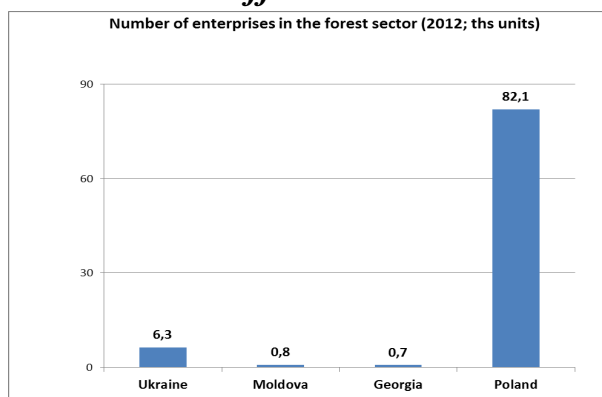


Fig. 7. Number of enterprises in forest sectors of different countries

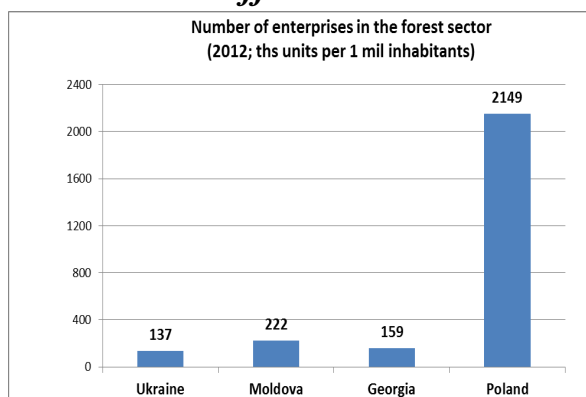


Fig. 8. Number of enterprises per million of inhabitants in forest sectors of different countries

Of course, there is considerable difference between price for forest sector's products in EU, particularly in Poland and in ENP countries but nevertheless we should derive value added from timber unit as much as possible because of exclusive ecological and economical mining of timber using sustainable development approach.

There is some fact in our researching which we can consider as a common disadvantage, as shortcoming using which we can characterize forest sectors of four countries from our searching list – forest sector's share does not exceed level of 2 % from national GDP (Fig. 12). And what is more, according our researching this share has tendency to constant decreasing, that we cannot consider as sustainability manifestation.

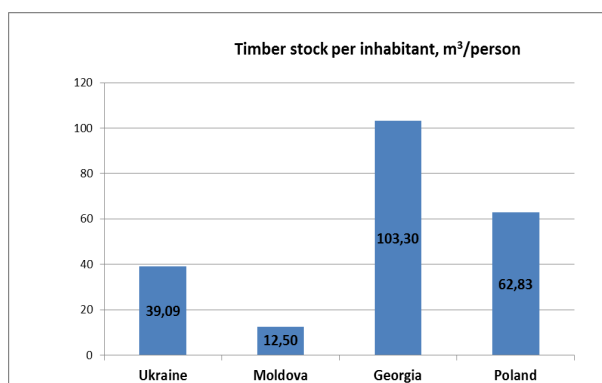


Fig. 9. Timber stock per inhabitant in forest sectors of different countries

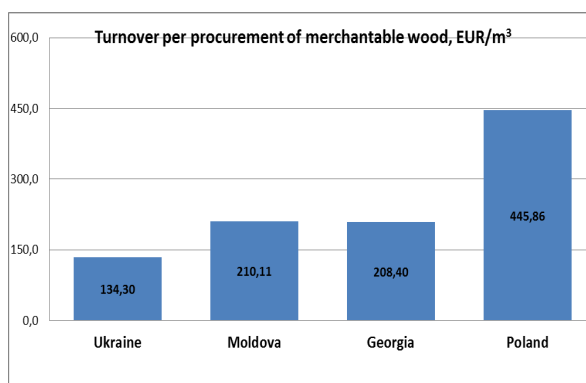


Fig. 10. Turnover per procurement of merchantable wood in forest sectors of different countries

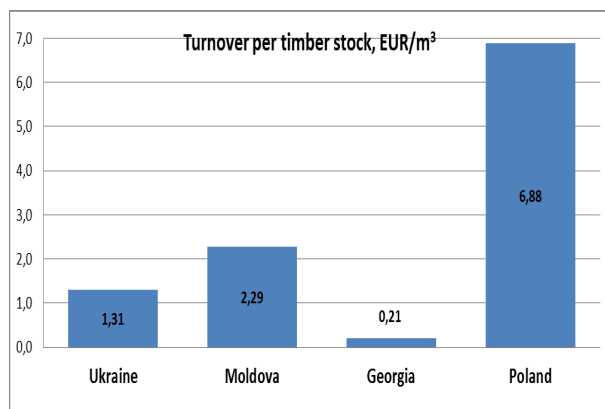


Fig. 11. Turnover per timber stock in forest sectors of different countries

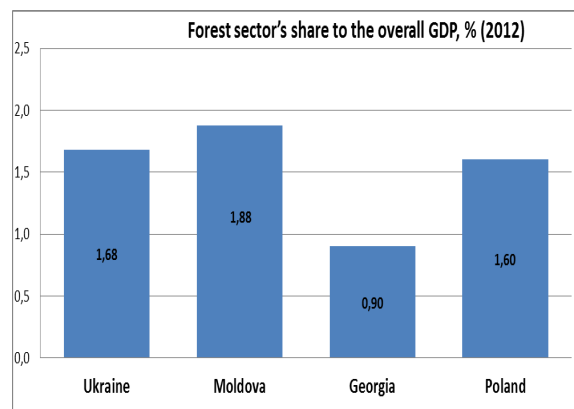


Fig. 12. Forest sector's share to overall GDP in different countries

Conclusions. As a result in the process of our researching we identify the following challenges of the sustainable production for woodworking industry in Eastern Europe.

1. Economical power of the forest sectors in Eastern Europe shifted towards forestry while secondary processing differs by poorer capacities and this fact hamper comprehensive sustainable development of these forest sectors, cause very poor value added.

2. Forest sectors in Earsten Europe differ by very poor productivity, since in average, one employee produces much less than in EU and therefore forest sectors in ENP countries need considerable productivity improving through, for instance new technologies, new tools and equipment, innovations and restructuring.

3. There are very few enterprises in forest sectors of ENP countries comparing with EU countries because of complicity of doing business here: availability of the timber in these countries, non-effectiveness of the state ownership in different areas of the forest sector, procedure of the timber resources sale.

4. Forest sectors of ENP countries produce much less products in in turnover terms from 1 m³ of procurement merchantable wood and from 1 m³ of overall timber stock as well and it is necessary considerable increasing of secondary treatment effectiveness.

5. Forest sector's share in ENP countries does not exceed level of 2 % from national GDP and there is tendency to constant decreasing of this share.

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Ресурсоефективність використання сировини у деревообробній промисловості Східної Європи: виклики і можливості для сталого розвитку

Представлено результати досліджень, які проведенні для лісового сектора. Дослідження базується на порівнянні лісових секторів трьох країн Східного партнерства (Україна, Молдова і Грузія) і лісового сектору Польщі. У процесі дослідження було визначено і проаналізовано основні економічні показники лісових секторів та лісових ресурсів для згаданих вище країн, проаналізовано внесок цих лісових секторів у ВВП країни. В результаті були визначені наступні проблеми сталого розвитку для деревообробної промисловості у Східній Європі: економічна міць лісового сектора в Східній Європі зміщена в бік лісового господарства; лісові сектори в країнах Східної Європи відрізняються дуже низькою продуктивністю; дуже мала кількість підприємств в лісових секторах країн Східного Партнерства в порівнянні з країнами ЄС через складність ведення бізнесу; лісові сектори країн Східного партнерства виробляють набагато менше продуктів з обороту; частка лісового сектора в країнах Східного партнерства не перевищує рівень 2% від національного ВВП і є тенденція до постійного зменшення цієї частки.

Ключові слова: лісовий сектор; оборот; кількість підприємств; кількість працівників; країни СЄП; лісових ресурсів; основні проблеми та можливості; сталий розвиток.

UDC 674.04

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PREDICTION OF THE DURABILITY OF THERMOPLASTIC ADHESIVE PINE WOOD JOINTS

Abstract. Presented here are the results of predicting the durability of thermoplastic adhesive joints of pine wood by means of mathematical models. An analysis was made of the obtained results, on the basis of which it is established that with increasing the ambient temperature, the durability of thermoplastic polyvinyl acetate adhesive pine wood joints with the degree of load D4 decreases, and when the ambient humidity increases, the durability, by contrast, is slightly increasing.