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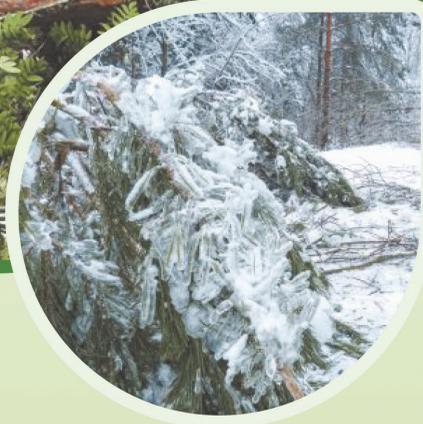
Global Facility for Disaster Reduction and Recovery



EDUCATIONAL INSTITUTION "BELARUSIAN STATE TECHNOLOGICAL UNIVERSITY"

# THE OVERVIEW OF EXISTING METHODS FOR THE HARVESTING, STORAGE AND SALE OF WOOD AFTER THE WINDBLOWS AND RECOMMENDATIONS FOR NEW METHODS OF HARVESTING AND MARKETING OF WINDBLOWN TIMBER TAKING INTO ACCOUNT THE POSSIBILITY OF FOREST INSURANCE

COMPONENT 2:  
SUPPORTING RESILIENCE  
AND RECOVERY  
IN THE FORESTRY  
SECTOR



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Minsk 2018





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## List of abbreviations

<b>GFDRR</b>	Global Facility for Disaster Reduction and Recovery
<b>SFE</b>	state forestry enterprise
<b>OJSC</b>	open joint stock company
<b>FLM</b>	fuel and lubricant materials
<b>RB</b>	Republic of Belarus
<b>ME</b>	Ministry of Emergencies
<b>Belarus NAS</b>	National Academy of Sciences of Belarus
<b>FLLC</b>	foreign limited liability company
<b>PCM</b>	pulp and cardboard mill
<b>CHP</b>	central heating and power plant
<b>BYN</b>	Belarusian ruble
<b>PPE</b>	personal protective equipment

## Executive summary

This report has been drawn up within the study of Component 2: Supporting resilience and recovery in the forestry sector funded by The Global Facility for Disaster Reduction and Recovery (GFDRR).

The report focuses on the issues related to timber harvesting, conservation and sales after the windblow that occurred in Belarus in 2016. The report contains evaluation of operational safety during logging operations on the windblown areas as well as review of approaches to forest insurance against adverse weather effects. The study and the review of best international practices served as a basis for recommendations for improving the efficiency of recovery operations after forestry catastrophic events in Belarus.

**On the main stage of the cycle of the recovery operations was timber harvesting on the affected areas.** The largest volume of timber was harvested from the areas of medium and heavy damage by means of clear cutting. Partial cuts were implemented on the areas of slight and small damage. In terms of the combination of factors the most common and advisable technological process is the technological process where cut-to-length is done onsite (on the logging area). The technological operations (tree felling, branch cutting and cutting into length) are done by harvesters or motor saws with the subsequent hauling of logs by special-purpose or trailed (carriages) forwarders to an intermediate yard. Multifunction machinery was preferred in terms of the operational safety and reduced time to complete the recovery operations.

**The harvested timber was conserved at intermediate yards in piles.** The conservation time ranged from several days to 2 months (in winter season). When the spring began, the price of the remained timber went down. However, due to relatively small volume of the stored timber (less than 1000 m<sup>3</sup>) and deconcentration of the materials, wet conservation of timber was not in place.

**Engineering personnel had regular on-site meetings with multifunction machinery drivers and crew workers to explain and instruct them in productive and safe working practices.** To ensure favourable working conditions and labour safety, new workwear, supplementary felling equipment (felling wedges, breaking bars, etc.) off-schedule and targeted safety instructions were regularly given to the workers. Temporary accommodation campuses for workers and service technicians were established in the forestry enterprises most affected by the windblow. The campuses had all conditions for year-round accommodation. The above measures and clear-up/salvage technologies as well as proper health safety control made it possible to avoid any accidents or personal injuries during the recovery operations.

**In 2016–2017, after the windblows had badly affected the forest fund of Belarus, the Ministry of Forestry took a top-down decision to stop most final cuts in order to ensure prompt clear-up operations on the windblow affected areas, to prevent sudden bringing of large volumes of timber onto the domestic market and subsequent price drops.** However, 6.0 million m<sup>3</sup> of commercial timber (115% of the 2015 exports) was exported in 2016 in order to sell the timber that was not demanded by the domestic market and to compensate for the losses incurred by the logging operations in the windblow affected areas. By a Presidential permit 3.7 million m<sup>3</sup> of round timber was exported. Potential supply markets were explored in order to identify timber buyers abroad. Export sales were effected at double price of the domestic level thus making it possible to compensate for the losses incurred by damaged wood harvesting and to avoid direct losses. Foreign currency earnings from the 2016 round timber export amounted to 83 million USD with profit margin of 25.4%. The ongoing modernization and construction of new woodworking facilities will lead to the consumption of 22.6 million m<sup>3</sup> of timber by 2020, including 15.9 million m<sup>3</sup> of commercial timber, 6.7 million m<sup>3</sup> of firewood. In the coming years about 23 million m<sup>3</sup> of timber can be easily consumed by the national forest sector in case of forestry catastrophic events.

In Belarus, in order to compensate the damage caused by natural disasters, there is a fund for financing expenses related to natural disasters, accidents and catastrophes, the volume of which for 2016 amounted for BYN 16.5 million or about \$ 8.25 million. It should be taken into account that the funds from the financing fund related to natural disasters, accidents and catastrophes are allocated not only to forestry. There is practice of fund allocation to the Ministry of Forestry for the development of windblows. However, compensation of expenses from the budget is closely related to the assessment of the amount of damage. Damage was calculated on the basis of obvious losses, mainly related to the costs of logging activities on the windblow sites, timber hauling, as well as the costs on business trips of workers and their accommodation. The costs required for reforestation were not taken into account. There exist the reserves to compensate the losses and costs incurred by forestry in the development and restoration of windblows but the task in this case is to properly assess them and justify the allocation of funds from the budget.

**Insurance is one of the mechanisms that to some extent allows to compensate the damage obtained by enterprises from natural disasters, accidents, catastrophes.** In Belarus, there is no forest insurance mechanism, however, there is experience in compulsory insurance with state support against weather risks of crops, livestock and poultry. This type of insurance is used in the Republic for almost 12 years and is carried out by the insurance company “Belgosstrakh”. Such a mechanism could theoretically be used to organize insurance of forest plantings, to compensate for the costs and losses associated with windblows.

**Completed studies allowed to make a number of conclusions and recommendations.**

Resilience of various tree species and their growth conditions must be taken into account to evaluate the efficiency of technological processes of logging operations on windblown areas.

Using of motor saws in the machine system for logging operations on the windblown areas requires high skills of saw operators, is highly hazardous and involves heavy physical activity of the workers. So, manual labour and hand motor tools can be justified only if machine systems cannot be applied for some operational or economic reasons. Use of the machine systems “harvester + forwarder” is most often justified in terms of operational safety, performance and time required to perform the work.

In case of a forestry catastrophic event (e.g., a windblow) it is recommended to apply the existing practice of final cuts suspension and to involve the resources of forestry enterprises in clear-up/salvage operations on the affected areas. This will prevent sudden bringing of large volumes of timber onto the market.

To permit export sales of small merchantable timber not demanded on the domestic market. The Government may establish quota as well as not restricting charges which will be allocated to finance forest regeneration, forest road repair and construction, technical re-equipment of forestry production, research projects aimed at improved efficiency of forest sector.

It is recommended to develop action plans for forestry catastrophic events that would provide for harvest and long-term conservation of more than 23 million m<sup>3</sup> of timber in special collecting depots, store houses of large woodworking enterprises and interseasonal storage yards of power facilities of the Ministry of Housing and Utility and the Ministry of Energy.

The insurance mechanism for forestry must take into account the risk of adverse weather phenomena for individual forestry institutions and take into account ongoing work on the improvement of forest resilience. The development of an insurance mechanism against windblows can be the next step after a wind hazard map for forestry institutions of Belarus and the development of measures aimed at improving the wind resistance of forest plantations.

# 1. Short analysis of methods for the harvesting and storage after the windblow in 2016

Clear-up/salvage operations after the 2016 windblow resulting in the damage of 6 million m<sup>3</sup> of timber were carried out in the following order:

- 1) emergency meeting in the Ministry of Forestry on the disaster response;
- 2) inspection of the affected areas and identification of the degree of damage to forest stands;
- 3) arrangement of cutting operations on the affected forested areas;
- 4) arrangement of conservation of the timber harvested;
- 5) timber transportation and sales;
- 6) forest regeneration on the affected areas;
- 7) forest roads repair and restoration.

The whole cycle of the recovery operations was completed in the period from July 13, 2016 to May 1, 2017.

On the main stage of the cycle was timber harvesting on the affected areas. The operations included:

- creation of command centres for logging operations in the most affected forestry enterprises, briefings of command centres;
- creation of temporary checkpoints of forest guards;
- creation of maintenance and repair stations for machinery;
- distribution of logging areas among forest users;
- creation of intermediate storage yards and storage facilities for the harvested timber;
- cutting operations;
- conservation of the harvested timber;
- clear-up of the logging areas from the logging waste;
- transportation of the harvested timber.

To reduce the time required to complete the recovery operations in the most affected forestry enterprises (SFE “Smolevichi leskhoz”, SFE “Cherven leskhoz”) all forestry enterprises of the sector were involved in the work as well as other forest users of various ownership forms.

The type of felling on the windblow affected areas was defined depending on the degree of damage (Table 1).

**Table 1. Classification of damage to forest stands**

Degree of damage	Type of damage			
	windblow	windfall	combined (windblow and windfall)	snowbreak
Slight	less than 20 %	less than 25 %	less than 20 %	less than 25 %
Small	21–40 %	26–45 %	21–30 %	26–45 %
Medium	41–65 %	46–70 %	31–50 %	46–70 %
Heavy	over 65 %	over 70 %	over 50 %	over 70 %

The largest volume of timber was harvested from the areas of medium and heavy damage by means of clear cutting. Partial cuts were implemented on the areas of slight and small damage.

Depending on the cutting operations, the sequence and the area (logging area, skidding track, upper or intermediate yard) the following technological processes of the felling operations were applied (Table 2).

In terms of the combination of factors (multifunction logging machinery, minimum manual labour, operational safety, forest road network, etc.), the most common and advisable technological process is the technological process TP-C1 where cut-to-length is done onsite (on the logging area). The technological operations (tree felling, branch cutting and cutting into length) are done by harvesters or motor saws with the subsequent hauling of logs by special-purpose or trailed (carriages) forwarders to an intermediate yard. At the intermediate yard the logs are piled with subgrading and then charged onto a log truck.

**Table 2. Technological processes of logging operations**

Abbreviation	Technological processes of logging operations
TP-C1	$L \rightarrow \frac{F}{La} + \frac{BC}{La} + \frac{CL}{La} + H + \frac{GP}{IY} + \frac{CL}{IY}$
TP-C2	$L \rightarrow \frac{F}{La} + \frac{BC}{La} + H + \frac{CL}{UY(IY)} + \frac{GP}{UY(IY)} + \frac{CL}{UY(IY)}$
TP-C3	$L, Ch \rightarrow \frac{F}{La} + \frac{BC}{La} + \frac{CL}{La} + H + \frac{GP}{IY} + \frac{R}{IY} + \frac{CL}{IY} + \frac{CCh}{IY}$

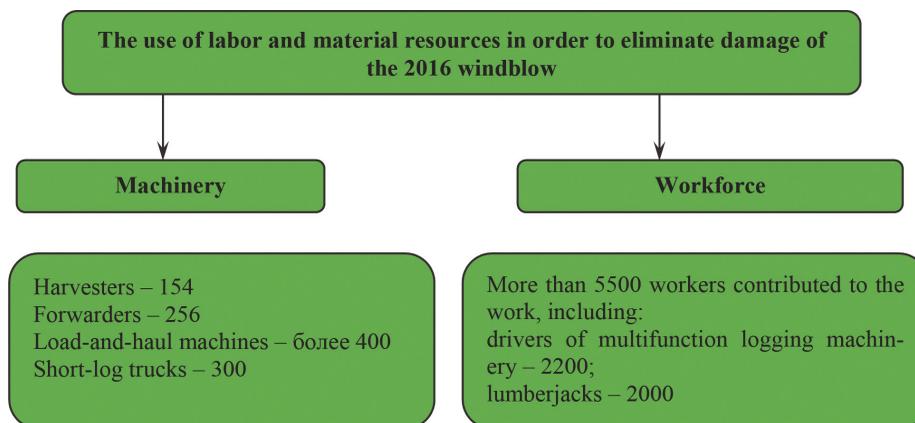
*Symbols* – L – logs; Ch – chips; La – logging area; UY – upper yard (IY – intermediate yard); F – tree felling; H – hauling; BC – branch cutting; CL – cutting into lengths; GP – grading-piling; R – reducing wood to chips; C – charging of wood onto log trucks.

If large volumes of low-graded firewood are available on the logging area and there is demand for chip fuel, technological process TP-C3 can be applied where low-graded wood is reduced to chips by mobile chipping machines at the intermediate yard and is then charged onto chip haulers.

Less common is technological process TP-C2 where cut-to-length operations are done at the upper yard with on-yard delivery of full-length logs and their further cutting. This process is efficient on low-load-bearing capacity soils.

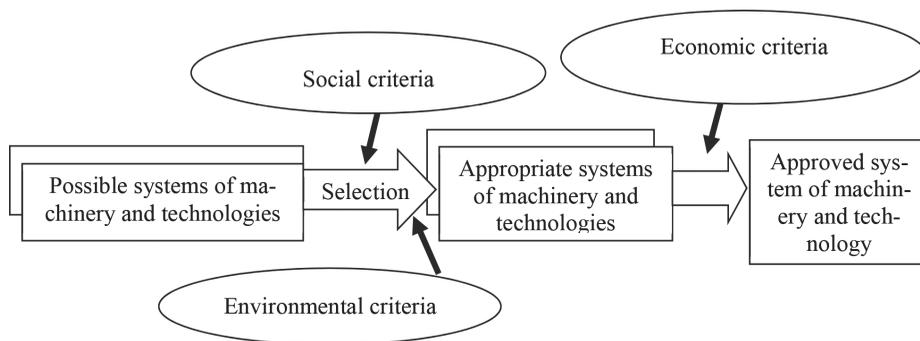
The technological processes were implemented by certain systems of machinery. Multifunction machinery (Figure 1) was preferred in terms of the operational safety and reduced time to complete the recovery operations.

**Figure 1. The use of labor and material resources in order to eliminate damage of the 2016 windblow**



The system of machinery and the respective technological process are selected stage by stage by the three groups of efficiency criteria. The conceptual diagram of the selection process is shown in Figure 2.

**Figure 2. Generalized diagram of the selection process for the system of machinery and technology of timber harvest**



In terms of the above requirements and criteria for the selection of machinery the following machines can be applied for cutting operations in the Republic of Belarus:

- for cut-to-length operations by **technological process TP-C1**:

Harvesters:

- for average full-length log volume  $V_{fl} = 0,2-0,3 \text{ m}^3$  Amkodor 2541, *Sampo R46*, *Ponsse Fox*, *Ponsse Beaver*;
- for average full-length log volume  $V_{fl} = 0,3-0,6 \text{ m}^3$  Amkodor 2561, *Komatsu 901*, *911.5*, *Ponsse Ergo W8*, *Ponsse Fox*, *Ponsse Beaver*;
- for average full-length log volume  $V_{fl} = 0,6-1,0 \text{ m}^3$  Amkodor 2561, *Komatsu 931.1*, *Ponsse Bear*;

*Motor saws* for tree felling *Stihl MS 261*, *361*, *440*; for branch cutting and cutting to lengths *Stihl MS 241*, *260*, as well as saws *Husqvarna*, which have similar power;

*Forwarders* Amkodor 2661-01, 2662, 2682, 2641; MLPT-354M; MLPT-344; *Komatsu 830.3*, *840*, *855*, *860.4*; *Ponsse Buffalo*, *Ponsse Elk*; *John Deere 1110G*; *Sampo FR28*; trailed forwarders (carriages) *MPT-461.1*, *MPT-471*, etc.;

- for cut-to-length operations by **technological process TP-C2**:

- for tree felling, branch cutting and cutting to lengths the same motor saws as for technological process TP-C1;
- for hauling: hauling tractors with cable-choker accessories *TTR-401M*, *TTR-411*, Amkodor *2242B*;
- for reducing wood to chips by **technological process TP-C3** mobile chipping machines: Amkodor *2904*, *MP-100*, *Jenz Hem-561*, etc.

Apart from the above recommendations, machinery and systems of machines should be selected in terms of soil conditions, areas of logging sites, size of forest stands and other factors based on technical and economic calculations.

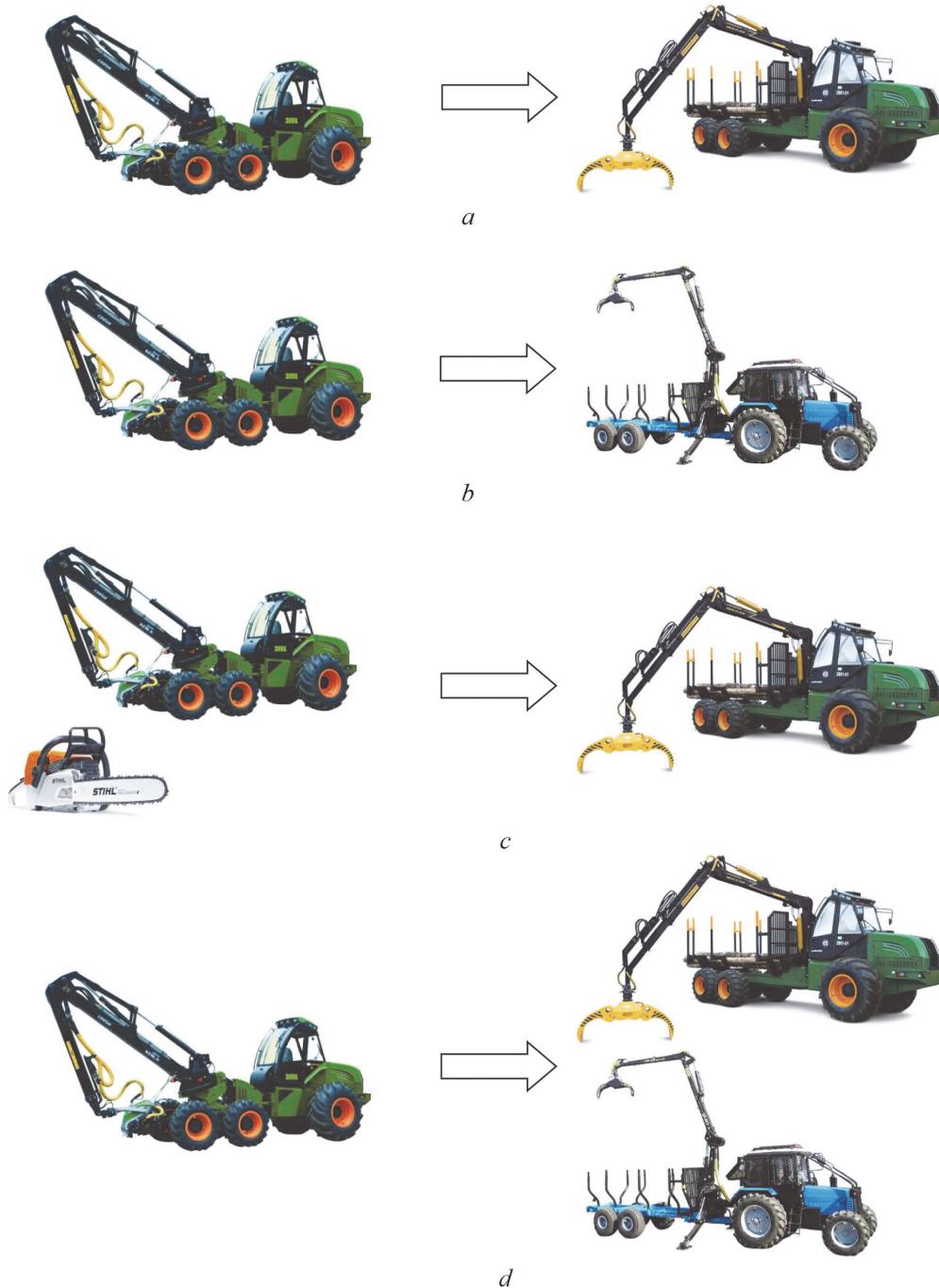
The Republic of Belarus has its own machine-building enterprises, therefore domestic machinery is preferred.

Arrangement of machines into systems can be done by the four schemes: by scheme 1 (Figure 3, a) a special-purpose forwarder with articulated frame is coupled with a harvester; by scheme 2 (Figure 3, b) a trailed forwarder is coupled with a harvester; scheme 3 (Figure 3, c) is applied

for semimechanical logging and includes a harvester and a motor saw that are coupled with a forwarder; by scheme 4 (Figure 3, d) a harvester is coupled with a special-purpose forwarder and a trailed forwarder.

The selection of a scheme depends on specific natural and production conditions and is done by ecological and economic substantiation.

**Figure 3. Schemes of arrangement of machines into systems**



**Scheme 1** is the most preferred one as it ensures fuller utilization of machines, compliance to their operation conditions, easier maintenance of the machines.

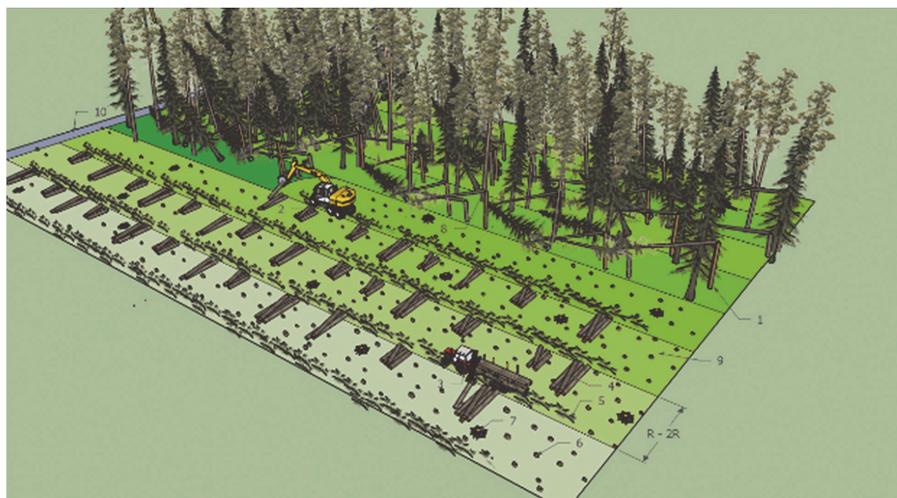
**Scheme 2** can be applied if trailed forwarders are available at the production facilities using motor saws. When applicable, the forwarders can transport full-length logs on the logging areas operated by harvetsers.

**Scheme 3** is most effective if conservation of the forest environment is required. However, it involves more manual labour.

**Scheme 4** can be effective if intermediate yards are located at long distance (1000-3000 m) from the timber harvesting areas or when soils have low-load-bearing capacity. This being the case, a special-purpose forwarder hauls timber from forest swaths to upper yard that is located within the borders of the logging area. A trailed forwarder carries the timber from the upper yard to the intermediate yard. A disadvantage of the scheme is that it requires more transporting operations.

Logging operations on the 2016 windblow affected areas were done by the following technological schemes (Figures 4–6).

**Figure 4. Technological scheme of logging operations on windblow affected areas by the machine system “harvester + forwarder”**



The technological scheme of logging operations by the machine system “harvester + forwarder” is the most efficient one as it ensures operational safety and makes it possible to meet the planned targets of harvesting volumes and deadlines of cutting operations.

The scheme shown in Figure 5 was also widely used during logging operations on the 2016 windblow affected areas because trailed carriages were abundant in forestry enterprises and the operations had rather low cost of work. However, it involves a lot of manual labour and more hazards as compared to machinery operations.

Use of hauling machines with cable-choker accessories (Figure 6) on the windblow affected areas was limited to swampy areas.

A promising scheme is a scheme of logging operation by the machine system “harvester + forwarder” with subsequent chipping of logging waste and low-graded timber by a mobile chipping machine (Figure 7). This scheme ensures a more comprehensive use of wood, conformity to sanitary conditions and better preparation of the logging area for the future forest regeneration.

Figure 5. Technological scheme of logging operations on windblow affected areas with at-the-stump cutting by the machine system “motor saw + forwarder”



Figure 6. Technological scheme of logging operations on windblow affected areas by the machine system “motor saw + hauling tractor with cable-choker accessories”



Figure 7. Technological scheme of logging operations on windblow affected areas by the machine system “harvester + forwarder + mobile chipper”



If the damage of slight and small character, it is recommended to do partial selective cuts (Figures 8-10) using both harvesters and motor saws.

Depending on the conditions of operations, performance and organization of work, a harvester can perform logging operations coupled with one or two forwarders.

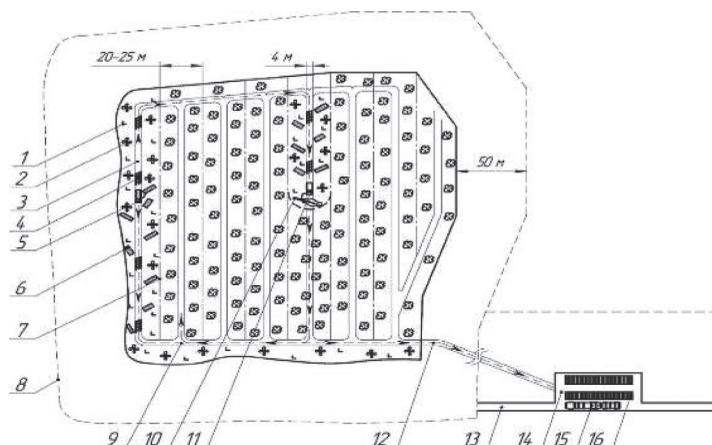
A harvester does logging operations in swaths (belts), their width depending on the manipulator radius. Both half-swaths are cut simultaneously with logway cutting. This being the case, trees in the logway are felled first. The order and direction of tree felling are planned at every harvester staying point. It is required to process all trees from every staying point using the manipulator radius.

Trees must be minimally moved when processed by a harvester. Required movement of a tree is done for branch cutting. If the soil is soft, the tree must be process in front of the machine in the way that the falling branches form a branch flooring protecting the soil cover. If the soil is stable, the trees can be processed on both sides of the machine.

Logways may form a straight line making the hauling operations easier or be unstraight as the harvester goes around individual trees and other obstacles. Unstraight logways reduce wind load on the forest stand.

All technological schemes having been considered, a feller does tree felling, branch cutting and cutting to length operations by a motor saw in case the areas are not accessible by harvesters or machine processing of trees is not possible (due to large diameter of trees, distorted shape, unhandy slope of the stem, etc.). Alternative logways on the cutting areas improve the efficiency of the system harvester – forwarder.

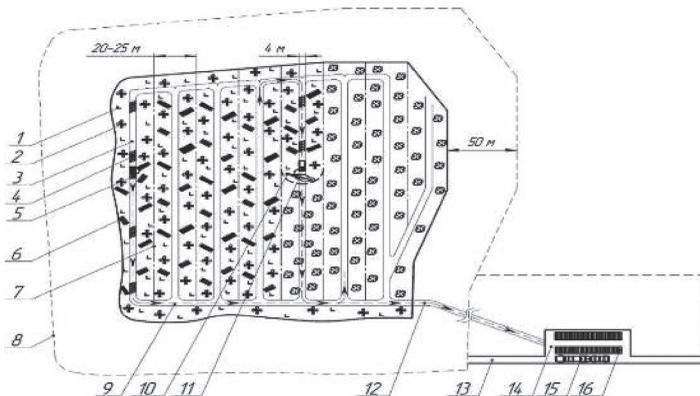
**Figure 8. Technological scheme of logging operations by harvesters and forwarders during partial cuts with alternating processing of swaths**



1 – stumps; 2 – trees cut subsequently; 3 – logway; 4 – logging waste placed on the logway; 5 – forwarder; 6 – full length logs; 7 – swath borders; 8 – safety zone borders; 9 – main logway; 10 – felled tree; 11 – harvester; 12 – temporary road to industrial yard; 13 – access way (forest road); 14 – intermediate yard; 15 – short log truck with hydraulic manipulator; 16 – log piles

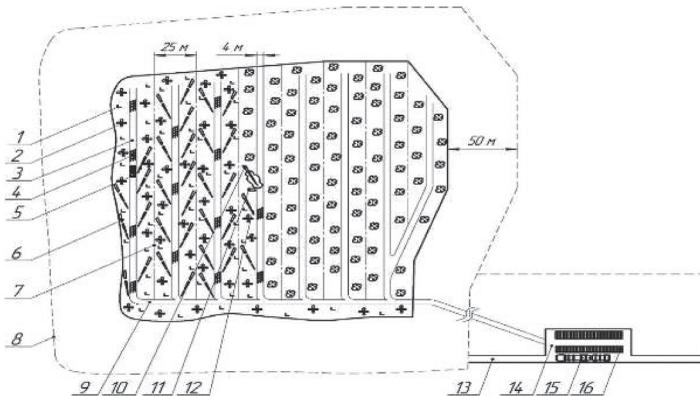
During partial cuts with motor saws (Figure 10) the felling area is split into 25 m wide swaths. The maximum width of the logway is 4 m. The direction of tree felling on a swath is determined so that they fall into gaps with minimum effect and damage to the remaining standing trees and young growth. Felling may be done on a backing-up tree.

**Figure 9. Technological scheme of logging operations by harvesters and forwarders during partial cuts with consecutive processing of swaths**



1 – stumps; 2 – trees cut subsequently; 3 – logway; 4 – logging waste placed on the logway; 5 – forwarder; 6 – full length logs; 7 – swath borders; 8 – safety zone borders; 9 – main logway; 10 – felled tree; 11 – harvester; 12 – temporary road to industrial yard; 13 – access way (forest road); 14 – intermediate yard; 15 – short log truck with hydraulic manipulator; 16 – log piles

**Figure 10. Scheme of logging operations by motor saws and forwarders during partial cuts with consecutive processing of swaths**



1 – stumps; 2 – trees cut subsequently; 3 – logway; 4 – logging waste placed on the logway; 5 – forwarder; 6 – full length logs; 7 – swath borders; 8 – safety zone borders; 9 – main logway; 10 – felled tree; 11 – harvester; 12 – temporary road to industrial yard; 13 – access way (forest road); 14 – intermediate yard; 15 – short log truck with hydraulic manipulator; 16 – log piles

Collecting, charging, delivery of full-length logs to intermediate yard, their grading and piling are done by a forwarder. The forwarder moves on the logway deep into the logging area. Collecting and piling of the full-length logs onto the cargo platform as the forwarder moves towards the intermediate yard. Preliminary subgrading of logs is done at this stage. At the intermediate yard the logs are piled accordingly (grading may be done at this stage).

The harvested timber was conserved at intermediate yards in piles. The conservation time ranged from several days to 2 months (in winter season). When the spring began, the price of the remained timber went down. However, due to relatively small volume of the stored timber (less than 1000 m<sup>3</sup>) and deconcentration of the materials, wet conservation of timber was not in place.

## 2 Assessment of the safety level of work in the development of windblow sites and the ways of improving it

To ensure favourable working conditions and labour safety, new workwear, supplementary felling equipment (felling wedges, breaking bars, etc.). Off-schedule and targeted safety instructions were regularly given to the workers. Engineering personnel had regular on-site meetings with multifunction machinery drivers and crew workers to explain and instruct them in productive and safe working practices (Figure 11).

**Figure 11. Logging operations in the windblow areas: a – by multifunction machinery, b – by motor saws**



Foresters were engaged in order to mobilize extra workforce for clear-up operations in the damaged stands. By the legislation in law, foresters may do cutting operations only within the boundaries of their assigned forestry districts; they are not allowed to perform any forestry-related operations in other forestry enterprises. So, the decision was taken to temporarily transfer them to do worker's job, but only if they agreed to do so.

24/7 checkpoints of state forest guards were established in order to monitor timber transportation (Figure 12).

**Figure 12. Checkpoints of timber transportation**



Temporary accommodation campuses for workers and service technicians were established in the forestry enterprises most affected by the windblow (Figure 13). The campuses had all conditions for year-round accommodation.

**Figure 13. Temporary accommodation campuses for workers and service technicians**



The above measures and clear-up/salvage technologies as well as proper health safety control made it possible to avoid any accidents or personal injuries during the recovery operations.

### 3. Sales of timber harvested from 2016 windblow in Belarus

Since 2015 the standing wood has not been traded with the exception of softleaved merchantable wood on the cutting areas of hard access. Timber sales on the domestic market are effected through the commodity exchange JSC Belarusian Integrated Commodity Exchange. The organizations under the Ministry of Forestry harvest timber and put the harvested timber out to tender.

Primary task of the forestry enterprises is to ensure sufficient timber supply to legal persons and individuals on the domestic market. Core buyers of commercial timber in Belarus are private companies, joint ventures and foreign companies that cover 65–70% of the total sales volume. Other major buyers are enterprises of Bellesbumprom concern, including those taken over by JSC “Development Bank of the Republic of Belarus”. The individuals buy 4–5% of the total volume of commercial timber. Over 2010–2017 there was a clearly marked upward tendency for round timber sales on the domestic market (Table 3).

**Table 3. Domestic market sales of round timber by the organizations of the Ministry of Forestry, thousand m<sup>3</sup>**

Indicator	2010	2011	2012	2013	2014	2015	2016	2017
Domestic market sales of timber	6088,5	6475,2	6353,6	6624	7963,4	8730	9337	12384
incl. commercial timber	2601,2	2770,8	2844,1	3045	4342,3	5167	5955	8020

As can be seen from Table 3, the domestic market sales of round timber by the organizations of the Ministry of Forestry have doubled over the period of 2010–2017 and amounted to 12.3 million m<sup>3</sup>. All domestic consumers were completely supplied by timber as prescribed by the governmental policy for domestic round timber processing and export sales of high added value products.

The export sales of timber are effected by the enterprises under the Ministry of Forestry residually, i.e., small-sized commercial timber (pulpwood, technical rawwood) for pulp-and-paper and wood panel production are put to external markets if there is no domestic demand (Table 4).

**Table 4. Export sales of timber by value and by volume by the organizations of the Ministry of Forestry**

Indicator	2010	2011	2012	2013	2014	2015	2016	2017
Export sales of timber: by volume, thousand m <sup>3</sup>	1771	1835	1914	2226	2090	2218	2600	1737
by value, million USD	105,9	133,8	111,6	144,8	164,3	124,0	140,0	147,0

As can be seen from Table 4 over 2010–2017 the export sales of timber increased both by value and by volume. The 2016 exports of round timber amounted to 2.6 million m<sup>3</sup> (up 146.8% on the 2010 sales). Maximum export supply by value was registered in 2017 and amounted to 147 million USD that is by 40% higher than in 2010.

It should be mentioned that timber was exported to 30 countries (Russia, Kazakhstan, Ukraine, Moldova, Azerbaijan, Uzbekistan, Austria, the UK, Belgium, Hungary, Vietnam, Germany, the Czech Republic, Denmark, Italy, Latvia, Lithuania, the Netherlands, Poland, Romania, Slovakia, Finland, France, Sweden, Estonia, Turkey, China, UAE, Cyprus, Kuwait). The share of export sales to the CIS market was 2%, that of the foreign countries – 98%. Poland (38.2% of value) is ranked first among the main export destinations of timber followed by Lithuania (16.6%), Latvia (10.6%), Germany (10.2%), Romania (8.1%) and the Netherlands (2.8%).

In view of the above, it is worth mentioning that there was no pricing policy for timber harvested from windblow areas. Therefore it was traded at the prices that were established for timber coming from final cut areas. The prices could be different for lower quality timber (lower grade).

Varying natural and production conditions, applied technology and machinery systems, transport accessibility and other factors contributed to constantly changing losses from logging operations in the windblow areas. Fluctuations of supply and demand resulted in fluctuating commodity exchange prices for timber.

The analysis of the fluctuations of exchange quotations of coniferous pulpwood prices, coniferous saw logs prices and technical rawwood made us arrive at the conclusion that prices vary only inconsiderably due to fluctuating supply and demand.

In 2016–2017, after the windblows had badly affected the forest fund of Belarus, the Ministry of Forestry took a top-down decision to stop most final cuts in order to ensure prompt clear-up operations on the windblow affected areas, to prevent sudden bringing of large volumes of timber onto the domestic market and subsequent price drops.

The forestry catastrophic events of 2016–2017 have considerably aggravated the assortment pattern of timber. Under normal conditions the commercial timber output amounts to 80%, that of firewood is 20%. The assortment pattern of timber after the windblows looked as follows: commercial timber – 40%, firewood – 60%.

Clause 29 of the Rules of Timber sales in the Domestic Market of the Republic of Belarus approved by Presidential decree No. 214 dated 07.05.2007 stipulates that exports of pulpwood, technical rawwood, plywood and saw logs is not allowed if unless otherwise provided by the President of the Republic of Belarus.

However, 6.0 million m<sup>3</sup> of commercial timber (115% of the 2015 exports) was exported in 2016 in order to sell the timber that was not demanded by the domestic market and to compensate for the losses incurred by the logging operations in the windblow affected areas. By a Presidential permit 3.7 million m<sup>3</sup> of round timber was exported (Figure 22). Potential supply markets were explored in order to identify timber buyers abroad. Export sales were effected at double price of the domestic level thus making it possible to compensate for the losses incurred by damaged wood harvesting and to avoid direct losses. Foreign currency earnings from the 2016 round timber export amounted to 83 million USD with profit margin of 25.4%. Average prices of round timber on the domestic market and for export supply are shown in Table 5.

**Table 5. Average prices of round timber sales in 2016**

Type of round timber	Sales price, USD	
	domestic market	export
Pulpwood	15,8	25,3
Technical rawwood	9,3	12,1
Saw logs	29,3	52,7

In 2017 the authorized exports of commercial round timber amounted to 1.77 million m<sup>3</sup>, including 1.19 million m<sup>3</sup> of pulpwood, 0.54 million m<sup>3</sup> of technical rawwood, 0.038 million m<sup>3</sup> of saw logs. The timber was sold with the profit margin of 41%. Thus, the opportunity to export round timber at higher prices made it possible to avoid direct losses from harvesting operations in the windblow affected areas.

On the whole the implementation of recovery operations after the 2016 windblow did not result in heavy losses of forestry enterprises due to two important resolutions taken by the government and the President, i.e., to decrease allowable final cuts and to authorize certain amount of round timber export. The decrease in allowable final cuts prevented round timber prices from dramatic fall both on the domestic and the CIS markets. The opportunity to export round timber and the resulting export profitability made it possible to compensate for the increased losses arising from

more complicated technology of the recovery operations, reduced rates of production, increased fuel consumption rates, degraded assortment pattern of timber, enhanced volume of waste wood during and after harvest.

Thus, financial support to the most affected forestry enterprises by Resolution of the Council of Ministers of the Republic of Belarus No. 633 dated 13.08.2016 “On allocation of public funding” was provided to the amount of 3 000 BYN or 18% of the total funds allocated to disaster management (16 500 BYN). Special permit of the President of the Republic of Belarus allowed exports of timber not demanded on the domestic market which made it possible to reduce the amount of the public funding. In 2016, revenues from selling 2.2 million m<sup>3</sup> of the windblow timber increased by 104 000 BYN, the profit went up by 32 000 BYN.

The recovery operations after the 2016 windblow made it possible to reveal some problem points related to cutting operations on windblow affected areas, interaction with other forestry enterprises involved in recovery operations and financing of forest regeneration and young plantations care. The fact is that forestry enterprises working on the affected forest areas accumulate all the income from timber sales. Therefore, the forestry enterprise with the windblow affected area (hereinafter referred to *as the affected forestry enterprise*) will find it difficult to maintain the same decent level of salary for the workers of the affected forest ranger stations and to provide financial support to young plantations care.

In view of the above, the current legislation of the Republic of Belarus provides for the following options of the clear-up/salvage operations in the forest fund involving third party contractors for different types of cuts (sanitary clear cuts, litter removal):

1. Allocation of affected standing forest to third parties without stock trading or through stock exchange. This option implies no costs for *the affected forestry enterprise*, whereas forest users pay stumpage value before obtaining the logging permit;
2. Allocation of affected standing forest to forestry enterprises without stock trading. *The affected forestry enterprise* bears no costs, the forestry enterprises either pay stumpage value before obtaining the logging permit or do sanitary cuts (clear or selective) as forestry measures without paying the stumpage value;
3. Involvement of third parties, including forestry enterprises, and selling of the harvested timber by *the affected forestry enterprise*.

The practices of recovery operations in the affected forest stands has proved **option 2** to be the most appropriate because it allows the affected forestry enterprise to accumulate proceeds as stumpage value for further funding of forest planting. This also makes it possible to partially compensate for additional costs (allowances, delivery of workforce and machinery, meals) and for lost earnings (harvesting and selling of mature wood on the own area) to the forestry enterprises assisting in clear-up/salvage operations. The optimum option here is to allocate 50% of the cutting area on the stumpage value paying conditions and 50% without paying the stumpage value.

Besides, to ensure funding of future forest planting *the affected forestry enterprise* should accumulate the excess receipts, e.g. on deposit, instead of funding any current tasks.

In order to cover the forest regeneration costs, apart from rational planning of excess receipts from stumpage value and timber sales it is necessary to plan forest planting costs for the coming years. Forestry enterprises must clearly understand which scope of forest regeneration will be done by their resources and which scope by third parties. So, the next year budgeting must allow for the funding of salary and extra charge or increased funding of other costs to finance the cost of services rendered to *the affected forestry enterprise*. Apart from budget funding of forestry activities, other budget sources must be considered such as forestry production loss recovery proceeds as well as funds for disaster recovery operations.

As to **option 3**, the excessive supply of timber and subsequent market price drop make rendering of services to *the affected forestry enterprise* less profitable because high contracting cost cannot be compensated by the price. Part of the extra costs (**option 2**) is covered by forestry enterprises themselves, so we can say that *the affected forestry enterprise* is to some extent subsidized by the forestry enterprises assisting in recovery operations on the affected forest areas.

An important factor is that under the limited demand for timber the forestry enterprises assisting in recovery operations also deal with timber selling, including the least merchantable type, i.e. firewood. One forestry enterprise is not able to sell all the timber which can result in considerable surplus and loss of useful qualities of timber.

Another problem issue is reduced salary of forest workers in the affected forestry enterprises due to decreased felling volumes.

Solution to this problem is related not only to the disaster recovery but to transformations that are promising for the sector and are connected with optimization of state forest protection and service market development. It is suggested to exempt forest workers from economic activities and to regulate the number of the forest workers respectively. The free funds resulting from the reduced number of forest workers will be allocated to increase the salary of the remaining workers. The redundant forest workers will be relocated to forest felling or other jobs. This problem will be solved by the service market development not only in the sphere of timber harvest but in forestry practices. The experiment will start in 2019 in 6 forestry enterprises.

Thus, to ensure more efficient and prompt sales of timber harvested from the areas affected by forestry catastrophic events it is required:

- to provide legislative support (to amend the Rules of Timber sales in the Domestic Market of the Republic of Belarus approved by Presidential Decree No. 214 dated 07.05.2007 “On some measures to improve forestry activities”) in order to introduce certain rates of sales of round timber harvested from the clear-up/salvage operations in the affected areas by the order established by the Ministry of Forestry, including direct off-exchange trading;
- to permit export sales of small merchantable timber not demanded on the domestic market. The Government may establish quota as well as not restricting charges which will be allocated to finance forest regeneration, forest road repair and construction, technical re-equipment of forestry production, research projects aimed at improved efficiency of forest sector;
- further modernization and expansion of rolling railway stock for forest cargoes.

**Applications of timber harvested from disaster effected areas.** Nowadays main timber harvesting organizations are those of the Ministry of Forestry of the Republic of Belarus (Table 6).

The data in Table 6 show that annually the organizations of the Ministry of Forestry harvest 55-70% of the total timber. Thus, the Ministry of Forestry must rely on the resources of its own subordinate organizations in case of forestry catastrophic events.

**Table 6. Harvesting of merchantable wood in 2011-2020 in the forests of forest fund holders of the Republic of Belarus, thousand m<sup>3</sup>**

Forest fund holders	2011	2012	2013	2014	2015
Republic of Belarus, total	16 129	15 981	16 455	16 929	18 514
including forests of:					
– Ministry of Forestry, total	14 818	14 662	15 077	15 550	17 135
including					
• Organizations of the Ministry of Forestry	9 200	9 500	10 500	11 000	13 000
• Bellesbumprom concern	2 600	2 600	2 000	2 000	2 000
• other timber harvesting organizations (outsourcing)	3018	2 562	2 577	2 550	2 135
– Department of Presidential Affairs of the Republic of Belarus	651	661	660	660	660
– OJSC «Vitebskdrev»	407	408	463	463	463
– other forest fund holders (Ministry of Defense, Ministry of Emergency, Belarus NAS, Ministry of Education, Minsk City Executive Committee)	253	250	255	256	256

The ongoing modernization of the existing and newly-built woodworking factories that started in 2007 has caused a considerable rise in commercial timber consumption. In 2006 the woodworking factories consumed 5.2 million m<sup>3</sup> of timber, in 2017 – about 12 million m<sup>3</sup>. The increased volumes can be explained by the modernization (primarily wood panel production facilities) of OJSC “Borisovdrev”, OJSC “Vitebskdrev”, OJSC “Gomeldrev”, OJSC “Ivatsevichdrev”, OJSC “Mozyrdrev”, OJSC “Mostovdrev”, OJSC “Rechitsadrev”, OJSC “FanDOK”, OJSC “Mogilevdrev” and construction of wood panel making factories FLLC “Kronospan” and FLLC “VMG-Industry”, etc.

It is expected that once the bleached sulphate plant of OJSC “Svetlogorskiy Pulp-and-Cardboard Mill” becomes fully operational and cardboard making plant of Dobrush paper factory “Geroy truda” is commissioned, additional 2.5 million m<sup>3</sup> of wood will be required.

Thus, the ongoing modernization and construction of new woodworking facilities will lead to the consumption of 22.6 million m<sup>3</sup> of timber by 2020, including 15.9 million m<sup>3</sup> of commercial timber, 6.7 million m<sup>3</sup> of firewood (Table 7).

**Table 7. Estimated balance of timber resources in the Republic of Belarus until 2025, thousand m<sup>3</sup>**

Indicators total	2015 (factual data)		2020 (estimation)		2025 (estimation)	
	total	incl. coniferous	total	incl. coniferous	total	incl. coniferous
<b>Timber harvest</b>	<b>18 472</b>	<b>12 437</b>	<b>23 556</b>	<b>13 025</b>	<b>25 012</b>	<b>14 390</b>
including:						
– commercial timber	12 144	7 714	16 897	10 146	17 934	11 210
incl.:						
saw logs	5 700	4 855	6 826	5 367	7 245	5 930
veneer logs	550	0	1 015	0	1 015	0
pulpwood bolts	2 809	2 069	5 221	3 223	5 542	3 602
technical rawwood	3 085	790	3 834	1 556	4 132	1 678
– firewood	6 328	4 723	6 659	2 879	7 078	3 180
<b>Domestic consumption of commercial round timber</b>	<b>8 953</b>	<b>5 955</b>	<b>15 887</b>	<b>9 500</b>	<b>16 198</b>	<b>10 050</b>
including:						
saw logs	4 962	4 466	6 300	5 350	6 600	5 900
veneer logs	549	0	1 015	0	1 015	0
pulpwood bolts	921	701	4 763	2 600	4 763	2 600
technical rawwood	2 521	788	3 809	1 550	3 820	1 550
<b>in the total consumption of Bellesbumprom concern</b>	<b>2 748</b>	<b>1 341</b>	<b>7 066*</b>	<b>3 739</b>	<b>7 066*</b>	<b>3 739</b>
including:						
saw logs	729	653	1 022	920	1 022	920
veneer logs	468	0	919	0	919	0
pulpwood bolts	221	221	3 063	2 097	3 063	2 097
technical rawwood	1 333	467	2 062	722	2 062	722

Indicators total	2015 (factual data)		2020 (estimation)		2025 (estimation)	
	total	incl. coniferous	total	incl. coniferous	total	incl. coniferous
<b>Free resources of commercial timber</b>	<b>367</b>	<b>289</b>	<b>1 010</b>	<b>646</b>	<b>1 736</b>	<b>1 160</b>
including:						
saw logs	248	229	526	17	645	30
veneer logs	1	0	0	0	0	0
pulpwood bolts	114	58	458	623	779	1 002
technical rawwood	4	2	25	6	312	128
<b>Export of commercial timber</b>	<b>2 824</b>	<b>1 470</b>	<b>**</b>	<b>**</b>	<b>**</b>	<b>**</b>
including:						
saw logs	490	160				
pulpwood bolts	1 774	1 310				
technical rawwood	560	0				

\* including needs (2.5 million m<sup>3</sup>) of the bleached sulphate plant of OJSC "Svetlogorskiy Pulp-and-Cardboard Mill" of the annual capacity of 400 thousand t (300 thousand t of coniferous timber and 100 thousand t of deciduous timber);

\*\* export volumes can be generated by free resources after the domestic market needs have been covered and by decisions of the Head of the State.

Analysis of the data in Table 7 shows that in the coming years about 23 million m<sup>3</sup> of timber can be easily consumed by the national forest sector in case of forestry catastrophic events. In other words, if a forestry catastrophic event (e.g., a windblow) leads to the damage of larger timber volume, it is advisable to arrange for long-term conservation of harvested commercial timber in special collecting depots, including those of large woodworking enterprises. Such events occurred in selected regions of Central and Western Europe (for instance, in Nouvelle Aquitaine (France) 32.8 million m<sup>3</sup> of timber on the area of 204 thousand ha was destroyed in 1999). Excessive firewood can be stored in depots of boiler rooms of the Ministry of Housing and Utility or co-generation plants of the Ministry of Energy which are the core buyers of wood fuel in the country, their annual consumption being about 4.5-5.5 million m<sup>3</sup>.

## 4. Possibilities and prospects of development of forest insurance against adverse weather conditions in Belarus

Unfavorable weather phenomena, especially of a catastrophic nature, such as the windblows of 2016, cause significant financial damage to forestry enterprises.

In 2016, according to the Ministry of Forestry, expenditures on windblows development amounted to about 140 million BYN (approximately \$ 70 mln). The main part of the costs was covered by the sale of wood on the domestic market and by exporting (137 mln BYN or 68.5 million dollars). Additionally, funding was required in the amount of approximately 3 million BYN or 1.5 million dollars.

In Belarus, in order to compensate the damage caused by natural disasters, there is a fund for financing expenses related to natural disasters, accidents and catastrophes, the volume of which for 2016 amounted for BYN 16.5 million or about \$ 8.25 million. The Ministry of Forestry has sent a request to the Council of Ministers for the deficient amount. According to the Regulation of the Council of Ministers of August 13, 2016 No. 633, an amount of 3 million BYN (approximately 1.5 million dollars) or 18% of the total amount of the fund for financing expenses related to natural disasters, accidents and catastrophes, was allocated for the development of hurricane-damaged plantings. At the same time, about 400 thousand rubles, or 2.4%, were allocated to the population for cost compensation of buildings and constructions restoration. In 2017, the allocation of funds for the elimination of windblow consequences continued. For example, for the restoration of the road network after the development of windblows, 1.5 million BYN or \$ 750 thousand were allocated.

Such a practice of fund allocation to the Ministry of Forestry for the development of windblows has been applied in the past years. Thus, in 2008, 6.2 billion Belarusian rubles or \$ 2.9 million were allocated (Regulation of the Council of Ministers of August 05, 2008 No. 1124), in 2004, 700 million Belarusian rubles or 321 thousand dollars were allocated to eliminate the consequences of windblow in Brest region (Regulation of the Council of Ministers of November 8, 2004 No. 1417), in 1998 – 10.4 billion Belarusian rubles or \$ 108 thousand (Regulation of the Council of Ministers of December 14, 1998 No. 1907).

However, compensation of expenses from the budget is closely related to the assessment of the amount of damage. Since Belarus did not experience such a large-scale windblows the damage was calculated on the basis of obvious losses, mainly related to the costs of logging activities on the windblow sites, timber hauling, as well as the costs on business trips of workers and their accommodation. The costs that are necessary for reforestation work that amounted for about 2 million BYN (about \$ 1 million), as well as the costs of carrying out agricultural tendings for the next 4 years and the costs of carrying out clarifications and cleanings in the first few decades, were not taken into account as these activities do not bring profit to forestry institutions. According to this, if to consider the issue for full damage compensation from the windblow from the state budget, it is necessary to provide for the annual reservation of funds in the fund for cost financing related to the natural disasters, accidents and catastrophes, at least until the first cost-efficient improvement felling.

On the other hand, the method for determining the total losses and costs of forestry from windblows developed at the first stage of this project showed that the damage from windblow is much higher. The difference is about 46.7 million BYN or 280% from the volume of the fund for financing expenses related to natural disasters, accidents and catastrophes.

It should be taken into account that the funds from the financing fund related to natural disasters, accidents and catastrophes are allocated not only to forestry. For example, with the volume of this fund budgeted for 2018, at 14.5 million BYN, only in the 3rd quarter of 2018, 30 million BYN were allocated to provide assistance to the entities operating in the field of agro-industrial production

through the funds provided in the Republican budget to finance the costs related to natural disasters, accidents and catastrophes. Thus, in the case of adverse weather phenomena both in forestry and agriculture, the burden on the budget increases significantly, which implies the withdrawal of funds from other budget items, for example, from the reserve fund of the President of the Republic of Belarus, which was budgeted in 2018 at 1.2 billion BYN or 600 million dollars.

Thus, there exist the reserves to compensate the losses and costs incurred by forestry in the development and restoration of windblows but the task in this case is to properly assess them and justify the allocation of funds from the budget.

However cost recovery options that reduce the burden on the Republican budget should be addressed.

Insurance is one of the mechanisms that to some extent allows to compensate the damage obtained by enterprises from natural disasters, accidents, catastrophes. However, there are certain features in the application of insurance for various sectors of the economy.

In world practice, forest insurance is provided in two directions: forest insurance against fires and comprehensive insurance, which also includes insurance against windblows, windbreaks, snow breaks and damage caused by wild animals. However, this type of insurance is mainly developing in countries with private forest ownership, as a private individual mostly isn't able to finance all the work on the development and restoration of damaged plantings. The use of state support funds in case of large-scale windblows leads to a budget deficit. For example, in France, as a result of state compensation payments to private forest owners, it was decided to introduce their insurance. At the same time, in case of large-scale windblows there are certain risks for the insurance companies related to the need for immediate compensation of significant amounts of money. In France, during the windblow of 2009 to cover insurance, the oldest insurance company MISSO was forced to sell two thirds of its assets.

In most countries, state forests are not insured. In this case, there is a redistribution of costs within the forestry organizations. In order to prevent the fall of wood prices in the domestic market, mechanisms such as, for example, limitation of fellings, exception are the windblow sites, are applied. Funds from the budget to compensate losses and costs are also required. In Latvia, in order to compensate losses from windblows in state forests, it is decided to reduce the amount of taxes for forestry for the next year.

When considering the issue of insuring state-owned forests, the key point is the ratio of insurance costs to the amount of funds that an insurance organization can compensate. And in most cases, the comparison is not in favor of insurance. For example, according to V. Petrov, the head of the Department of Forest Policy, Economics and Management of St. Petersburg Forestry University, with the existing volumes of forest rent in Russia and the possible amount of insurance contributions, insurance companies will collect an amount approximately equal to the annual amount of funding allocated to the country's forestry.

In case of local windblows, state-owned enterprises are able to implement all the necessary work themselves, and the costs are covered by other incomes. In case of large scale windblows, there is a risk of non-payment by private insurance companies, which they perfectly understand and include this risk in the amount of the insurance contribution. However, there is a practice of attracting foreign capital through agreements with foreign insurance companies, as the Russian Challenge Group does.

In Belarus, there is no forest insurance mechanism, however, there is experience in compulsory insurance with state support against weather risks of crops, livestock and poultry. This type of insurance is used in the Republic for almost 12 years and is carried out by the insurance company "Belgosstrakh". This type of insurance provides for state support at the level of 95% of the amount of the insurance contribution, through the financing by the Republican fund for producers of agricultural products, food and agricultural science support. The remaining 5% is paid by the enterprise.

The interest of damage compensation for the death of crops, livestock and poultry, insurance rates, as well as the list of crops for which insurance is carried out, is annually provides by a presidential decree of the Republic of Belarus.

Such a mechanism could theoretically be used to organize insurance of forest plantings, to compensate for the costs and losses associated with windblows, however, taking into account the specifics of forest management, a sufficiently large range of problematic issues, such as setting the amount of the sum insured and the insurance rate, determining the mechanism and source of compensation, determining the parameters according to which compensation will be paid, etc.

Unlike agriculture, where the period of production is mainly 1 – 3 years, in forestry the period of production is the same as the felling turnover. It can reach 100 – 120 years. During this period, the amount of the paid insurance contribution may be an impressive amount, and an insured event due to the inconstancy of winblows, may not occur.

It should be borne in mind that with the death of agricultural crops, most of the crop is lost. In the case of a windblow a change in the assortment structure occurs, however, it remains possible to realize a significant part of the planting stock, thereby reducing the loss of forest enterprises. In addition, the existing imbalance between the prices for roundwood in the external and domestic markets allows, by increasing the share of exports, to generate additional income covering forest losses from windblows.

Thus, in the present conditions of roundwood export limit it is advisable to cover the costs for the development of windblows, their reforestation and tending of the created forest cultures to request annually export quotes that will allow to compensate the costs of forestry of the Republic for the appropriate stage of measures to eliminate the effects of windblows. It will reduce the burden on the budget, since it will reduce payments from the fund to finance expenditures related with natural disasters, accidents and catastrophes. To prevent corruption schemes, the sale of additional wood for export can be carried out centralized under the control of the Ministry of Forestry. The proceeds should be sent to the affected forestry enterprises. It will allow them to finance relevant activities. Attracting additional funding for reforestation and carrying out tending can have a stimulating effect on the development of the service market in this field in the Republic of Belarus.

Forest insurance may appear in Belarus in the future, after a comprehensive assessment by government bodies of feasibility and effectiveness for the conditions of Belarus. As in the existing cost recovery scheme and in insurance, budget money will play the main role.

However, the insurance mechanism for forestry must take into account the risk of adverse weather phenomena for individual forestry institutions and take into account ongoing work on the improvement of forest resilience. Ideally, insurance should serve as a tool to stimulate measures to reduce fire danger and increase wind resistance of plantings. The development of an insurance mechanism against windblows can be the next step after a wind hazard map for forestry institutions of Belarus and the development of measures aimed at improving the wind resistance of forest plantations.

## 5. Recommendations based on the international experience for new methods of harvesting and marketing of windblown and other salvaged timber. Approaches to the insurance of forest stands in Belarus

**The study on the performance evaluation of logging operations in the windblow cutting areas made the following conclusions and recommendations possible.**

The above classification of the windblow affected forests provides a proper arrangement of the various occurring forms, types and degrees of damage incurred to forest stands. Such factors as tree breakage or pulling out, ratio of damaged and intact trees on the cutting area, direction of the tree fall on the limited area have a considerable effect on the selection of machinery and technology, operational efficiency, quality of the product, operational safety and other important performance indicators of forestry activities. For instance, medium to heavy damage degree in a windblown spruce forest considerably aggravates the performance of harvesters. During logging operations on the cutting areas with randomly fallen trees, the harvester performance may be lower than that of motor saws and tractors with choker accessories. Feller-delimber-bunchers have no difficulty in operating on windblown cutting areas (pine forests), so there is no need to replace them by portable chain saws.

Resilience of various tree species and their growth conditions must be taken into account to evaluate the efficiency of technological processes of logging operations on windblown areas.

When improvement fellings are carried out on the areas that are exposed to strong winds, it is advisable to take some preventive actions to prepare the trees to wind exposure, i.e., trees growing on more open areas, e.g., edge of the forest, and more frequently exposed to wind become more wind-resistant, their roots become stronger on the upwind side.

An important thing is to create conditions for decreasing the windblow probability and improving the resistance of future or growing forest stands. To achieve this, the cutting is carried out on the downwind side or windward, the sequence of operations is carefully planned in advance.

Using of motor saws in the machine system for logging operations on the windblown areas requires high skills of saw operators, is highly hazardous and involves heavy physical activity of the workers. So, manual labour and hand motor tools can be justified only if machine systems cannot be applied for some operational or economic reasons.

Use of the machine system “motor saw – trailer tractor with choker accessories” is recommended for logging areas with average volume of full-length logs less than 0.5 m<sup>3</sup> and on soils of types II and III in mixed and deciduous stands. For soils of type III special measures to improve manoeuvrability of the trailer tractors should be developed.

If windblow results in considerable contamination of stems by mechanical impurities, logging operations during snow-free seasons should be done with carbide saw chains (chaff cutters).

Selection of hauling machinery should be done in terms of average volume of full-length logs and soil conditions. In any case the hauling machines must be equipped with a hoist having a cable of minimum 40 m or a manipulator radius of minimum 6 m and a load moment of 50–100 kN·m as well as a pusher.

Use of the machine systems “harvester + forwarder” is most often justified in terms of operational safety, performance and time required to perform the work. However, the efficiency of multifunction machinery for logging operations on the windblown cutting areas is much lower than under normal conditions, therefore their application must be proved by technical and economic calculations.

An extensive windblown area that is heavily damaged and has randomly fallen trees is recommended to be split into swaths with logways to eliminate difficulties and hazards for the machines going deep into the area and to provide a traffic corridor. Such areas should be processed by a harvester moving clockwise (or counter clockwise) around the periphery inward the area.

Two fellers are usually engaged in preparing the cutting area for the harvester operation. They notch damaged trees that are not accessible by the harvester. Final clean-up operations are also done manually.

When the machine systems “harvester + forwarder” is selected for logging operations on the windblown cutting areas, machines with maximum service life are involved for working under the heavy-wear conditions. Damaged stands are first processed by a harvester on the upwind side to facilitate tree gripping and their hauling to the processing site. The most difficult sites with randomly piled trees are operated in the last turn. After the logging area has been cleared up, the sites can be accessed from all sides. The operator himself selects the logging technology based on his experience and skills.

Taking into consideration the fact that windblown cutting areas abound in low-graded wood, it is advisable to involve mobile chippers (for wood stock not less than 1000 m<sup>3</sup>) in order to ensure rational use of wood biomass.

When machines are arranged in the systems by models and by quantity, it is necessary to follow the basic principles of the machine systems arrangement: the performance capacity of the machines should be similar or many-fold and multifunction or more costly machines must not stand idle; the machines in the systems should be built on the same base to ensure serviceability and replaceability of certain units and elements; dimensions and radii of the machine turn should be rather similar, etc.

Taking into account the international practices, the following sequence of logging operations is recommended:

- create transport accessibility of the damaged areas;
- priority harvesting of commercially valuable timber;
- removal of individual damaged trees to prevent secondary damage by pests;
- clear-up of large windblow affected areas;
- long-term conservation of timber of resilient species;
- harvesting of low-grade and small-sized timber of broadleaved species is to be done in the last run.

Performance of liquidation of consequences of windfalls in this sequence reduces the cost of these activities and increases the shelf life of the wood.

Due to the possibility of reducing the cost of wood raw materials in the market after the windfall to maximize financial benefit and prevent a strong fall in wood prices, the storage of large volumes of timber at specially organized sites can become a necessary measure for several years.

During the operations main existing national rules of operational safety must be observed.

The logging operations on the windblown areas can be done only by workers with proper professional training, age, gender, health condition, qualification, professional development and duly instructed on operational safety.

All workers must follow health and safety rules and the rules of conduct on the industrial premises, at production facilities, in utility and personal service rooms. They must know how to use personal and collective protective equipment and immediately inform the administration about any situation that can threaten life and health of the working personnel and general public, as well as about any industrial accidents or aggravation of their health. They must also render any assistance to the injured and help to deliver them to health care organizations.

During the technological process all the workers in the zone of operation must know where safety equipment, first aid kits, fire extinguishers are located.

All workers must be equipped with personal protective means. All machines driven by operators (tractor drivers, drivers) must have safety belts. Equipment operators must use (or carry on themselves if necessary) safety belts.

Chain saw operators must wear foot protection and safety shoes. Their work clothes must be well visible and contain light reflecting elements.

All people involved in timber harvesting operations must follow fire safety rules in the forests of the Republic of Belarus.

**Thus the study makes the following conclusions possible:**

- 1) in case of a forestry catastrophic event (e.g., a windblow) it is recommended to apply the existing practice of final cuts suspension and to involve the resources of forestry enterprises in clear-up/salvage operations on the affected areas. This will prevent sudden bringing of large volumes of timber onto the market. Such practices are also very important taking into consideration the fact that organizations of the Ministry of Forestry harvest about 55-70% of the total national harvest of timber;
- 2) it is recommended to allocate the damaged forest areas to the assisting forestry enterprises without stock trading: they either pay stumpage value before obtaining the logging permit or do sanitary cuts (clear or selective). It allows the affected forestry enterprise to accumulate proceeds as stumpage value for further funding of forest planting as well as to partially compensate for additional costs (allowances, delivery of workforce and machinery, meals) and for lost earnings (harvesting and selling of mature wood on the own area) to the forestry enterprises assisting in clear-up/salvage operations. The optimum option here is to allocate 50% of the cutting area on the stumpage value paying conditions and 50% without paying the stumpage value;
- 3) to ensure funding of future forest planting the affected forestry enterprise should accumulate the excess receipts, e.g. on deposit, instead of funding any current tasks;
- 4) it is efficient to involve other forestry enterprises in recovery operations as they also deal with timber selling, including the least merchantable type, i.e. firewood. One forestry enterprise is not able to sell all the timber which can result in considerable surplus and loss of useful qualities of timber;
- 5) special permit of the President of the Republic of Belarus allowed exports of 2.2 million m<sup>3</sup> of timber not demanded on the domestic market which resulted in extra revenues to the amount of 104 million BYN and profit of 32 million BYN. This made it possible to partially compensate for the losses of the forest sector and to minimize the paid amount of the funds allocated to disaster management to 3 million BYN (the total fund is 16.5 million BYN). Taking into consideration the above facts it is recommended:
  - to provide legislative support (to amend the Rules of Timber sales in the Domestic Market of the Republic of Belarus approved by Presidential Decree No. 214 dated 07.05.2007 “On some measures to improve forestry activities”) in order to introduce certain rates of sales of round timber harvested from the clear-up/salvage operations in the affected areas by the order established by the Ministry of Forestry, including direct off-exchange trading;
  - to permit export sales of small merchantable timber not demanded on the domestic market. The Government may establish quota as well as not restricting charges which will be allocated to finance forest regeneration, forest road repair and construction, technical re-equipment of forestry production, research projects aimed at improved efficiency of forest sector;
- 6) it is recommended to develop action plans for forestry catastrophic events that would provide for harvest and long-term conservation of more than 23 million m<sup>3</sup> of timber in special collecting depots, store houses of large woodworking enterprises and interseasonal storage yards of power facilities of the Ministry of Housing and Utility and the Ministry of Energy;
- 7) transformations aimed at optimizing the forest protection services and service market development hold promise for the forest sector. It is necessary to exempt forest workers from economic activities and to optimize the number of the forest workers respectively. The free funds resulting from the reduced number of forest workers may be allocated to increase the

salary of the remaining workers. The redundant forest workers may be relocated to forest felling or other jobs. In the long term the service market development is required not only in the sphere of timber harvest but in the field of forestry activities.

**The study of insurance issues made it possible to formulate the main approaches to insuring forest plantations in Belarus from adverse weather conditions:**

- In Belarus, in order to compensate the damage caused by natural disasters, there is a fund for financing expenses related to natural disasters, accidents and catastrophes, the volume of which for 2016 amounted for BYN 16.5 million or about \$ 8.25 million. It should be taken into account that the funds from the financing fund related to natural disasters, accidents and catastrophes are allocated not only to forestry;
- There is practice of fund allocation to the Ministry of Forestry for the development of windblows. However, compensation of expenses from the budget is closely related to the assessment of the amount of damage. Damage was calculated on the basis of obvious losses, mainly related to the costs of logging activities on the windblow sites, timber hauling, as well as the costs on business trips of workers and their accommodation. The costs required for reforestation were not taken into account;
- There exist the reserves to compensate the losses and costs incurred by forestry in the development and restoration of windblows but the task in this case is to properly assess them and justify the allocation of funds from the budget;
- Insurance is one of the mechanisms that to some extent allows to compensate the damage obtained by enterprises from natural disasters, accidents, catastrophes;
- In Belarus, there is no forest insurance mechanism, however, there is experience in compulsory insurance with state support against weather risks of crops, livestock and poultry. This type of insurance is used in the Republic for almost 12 years and is carried out by the insurance company “Belgosstrakh”. Such a mechanism could theoretically be used to organize insurance of forest plantings, to compensate for the costs and losses associated with windblows;
- In forestry the period of production is the same as the felling turnover. It can reach 100 – 120 years. During this period, the amount of the paid insurance contribution may be an impressive amount, and an insured event due to the inconstancy of windblows, may not occur;
- In the present conditions of roundwood export limit it is advisable to cover the costs for the development of windblows, their reforestation and tending of the created forest cultures to request annually export quotes that will allow to compensate the costs of forestry of the Republic for the appropriate stage of measures to eliminate the effects of windblows. It will reduce the burden on the budget, since it will reduce payments from the fund to finance expenditures related with natural disasters, accidents and catastrophes;
- The insurance mechanism for forestry must take into account the risk of adverse weather phenomena for individual forestry institutions and take into account ongoing work on the improvement of forest resilience. The development of an insurance mechanism against windblows can be the next step after a wind hazard map for forestry institutions of Belarus and the development of measures aimed at improving the wind resistance of forest plantations.







