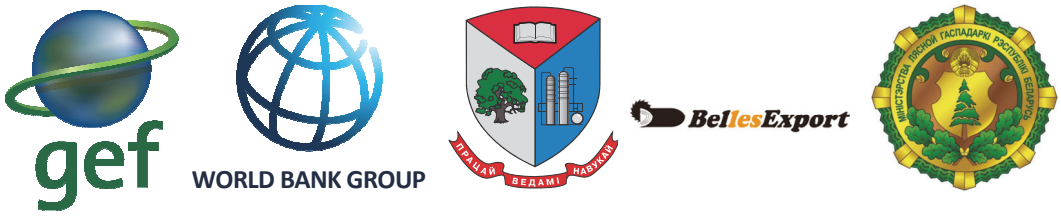

MINISTRY OF FORESTRY OF THE REPUBLIC OF BELARUS

Educational Institution
"BELARUSIAN STATE TECHNOLOGICAL UNIVERSITY"

ECOLOGICALLY ORIENTED FORESTRY DEVELOPMENT IN BELARUS IN THE CONTEXT OF CLIMATE CHANGE

Minsk
BSTU
2019

УДК 630*:161.32:630*907.3:630.6+502.17

Ecologically Oriented Forestry Development in Belarus in the Context of Climate Change / I.V. Voitau [et al.] ; eds. I.V. Voitau, V.G. Shatravko. – Minsk : BSTU, 2019. – 182 p. – ISBN 978-985-530-751-9.

This brochure is a result of implementing Activity 3.1.4: Consultancy Services to Develop Strategies and Actions Plans for the Adaptation of the Belarusian Forestry Sector to Climate Change and to Implement the Principles of "Green Economy" under Contract № BFDP/GEF/CQS/16/25-26/17 dated October 23, 2017, within the Belarus Forestry Management Project (TFOA1173 GEF/World Bank). It incorporates conceptual approaches to forest management in Belarus in the context of weather and climate change observed in recent decades. The brochure addresses the ways of combating adverse climate change impacts on the forestry, the challenges of reforestation, afforestation and forest tending techniques in order to adapt them to climate change. The report includes analysis of contribution of the Belarusian forestry to climate change mitigation as concerns atmospheric carbon dioxide absorption by forests and its partial sequestration as phytomass carbon, soil organic carbon and other forest fund components. The "green economy" principles and criteria have been developed for the Belarusian forestry, the ways to promote them in the emerging "green economy" have been proposed. A new concept of sustainable forest management has been formulated, which is based on the climate-oriented strategy of forestry development.

The publication is intended for specialists and researchers in the field of forestry, ecology, economics, environmental management, etc.

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This publication was prepared under the Belarus Forestry Development Project with the grant funding support of the Global Environment Facility (GEF). *The findings, interpretations, and conclusions expressed in this report do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent, and the GEF agencies and donors. The World Bank and GEF do not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank and GEF concerning the legal status of any territory or the endorsement or acceptance of such boundaries*

ISBN 978-985-530-751-9

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LIST OF MAIN ABBREVIATIONS, SYMBOLS, UNITS OF MEASUREMENT, TERMS AND DEFINITIONS

The following main abbreviations, symbols, units, terms and their definitions are used in the present publication:

Belarus NAS: National Academy of Sciences of Belarus;
BFF: Boiler and furnace fuels
CHP: Central Heating and Power Plant;
EII: Eco-Innovation Index;
EPI: Environmental Performance Index;
EU: European Union;
FAO: United Nations Food and Agriculture Organization;
FSC: Forest Stewardship council;
GDP: Gross domestic product;
GEI: Green Economy Initiative;
GGEI: Global Green Economy Index;
GIS: Geographic Information System;
IPCC: Intergovernmental Panel on Climate Change;
LULUCF: Land use, Land-use Change and Forestry
Minleskhoz: Ministry of Forestry of the Republic of Belarus;
PEFC: Programme for the Endorsement of Forest Certification;
R&D: Research and Development;
RB: Republic of Belarus;
RBTS: Planting material - root-balled tree system
RES: Renewable energy source;
ROSHYDROMET: The Federal Service for Hydrometeorology and Environmental Monitoring of Russia;
SFE: State Forest Enterprise;
SI: State Institution;
SPFA: State Production Forestry Association;
SPNA: Specially Protected Natural Areas;
TCP: Technical Code of Common Practice;
UN: United Nations Organization;
UNECE: United Nations Economic Commission for Europe;
UNEP: United Nations Environment Programme;

UNFCCC: United Nations Framework Convention on Climate Change;

WMO: World Meteorological Organization;

C: carbon;

CO_2: carbon dioxide;

CV: share of carbon (C) in the stand components per one unit of stemwood volume, tC/m^3;

P: average density of forest stands;

N_2O: nitrous oxide;

CH_4: methane;

O_2: atmospheric oxygen;

No.: number;

ha: hectare;

m^3/ha: cubic metre per hectare;

°C: Celsius degree;

%: percent;

g: gram;

t: ton, 10^6 g, megagram;

Gg – 10^9 g, gigagram, 10^3 t, thousand t;

Tg – 10^{12} g, teragram, 10^6 t, million t;

Ash: *Fraxinus excelsior*;

English oak: *Quercus robur*;

European alder: *Alnus glutinosa*;

European beech: *Fagus sylvatica*;

European larch: *Larix decidua*;

European spruce: *Picea abies*;

European white birch: *Betula pendula*;

Grey alder: *Alnus incana*;

Hornbeam: *Carpinus betulus*;

Menzies Douglas fir: *Pseudotsuga Menziesii*;

Scots pine: *Pinus sylvestris*;

Sessile oak: *Quércus pétraea*;

Silver fir: *Abies alba*;

Small-leaved linden: *Tilia cordata*;

White fir: *Abies concolor*;

CO_2 absorption: absorption of carbon dioxide from atmospheric air, tCO_2;

forest carbon budget: collection of information about the carbon stock and flows in forest fund;

annual absorption of carbon dioxide by forest: accumulation of carbon dioxide fixed in the annual increment of phytomass, dead phytomass and organic soil carbon per one hectare of forest fund. It is defined as a difference between the capacity of atmospheric CO_2 fixation during the photosynthesis of forest vegetation ("total photosynthesis"), on the one hand, and total CO_2 emission as a result of vegetation and soil respiration, wood harvesting (logging), forest fires, forest damage by pests and diseases, burning of logging residues on felling sites, on the other hand, tCO_2/ha/year;

Green economy – is an economy model that is aimed at growth and social development be using primarily intensive factors, while reducing impacts on natural resources and environmental risks;

forest components in carbon flows calculations: overground phytomass, underground phytomass, dead phytomass, organic soil carbon;

forest carbon cycle: ongoing process of mutual carbon absorption of atmospheric carbon by forest vegetation during photosynthesis with the formation of organic substances, partial deposition of carbon in phytomass and soil or its subsequent atmospheric re-entry during vegetation respiration and dead phytomass mineralization in forest;

forest fund: forest and non-forest lands;

forest lands: lands of the forest fund including forested and non-forested lands, which are designated for forest growing;

forest cover: share of lands covered with forest in the total area under consideration;

small biological forest cycle: sequence of processes of the entry of soil and atmospheric substances into vegetation, return of life substances into soil and atmosphere and their conversion into the compound substances absorbable by forest vegetation;

dead forest phytomass: total organic substance amount contained in the forest floor, dead standing trees, windfallen trees, dead / fallen branches, roots and stumps forest under storey and forest live cover in the forest lands;

growing stock: the total volume of wood defined by forest inventory and not including the wood felled during the entire forest stand's lifespan and the mortality volume. Growing stock is an actual stock which determines the current productive capacity of the forested area;

non-forest lands: lands belonging to forest fund but not intended for forest growing;

carbon net flow: carbon exchange between ground ecosystems and atmosphere;

complete stand: a stand having such a structure, species, age and growing conditions to be considered the most perfect-quality (M.M. Orlov), a stand with the relative density of 1.0;

total change of forest-sequestered carbon: difference of total forest carbon between the current and the previous years, tC/year;

organic soil carbon: carbon content in the upper 30-cm layer of sandy, sandy-loam and clay-loam soils all the way down to the peat layer of wet peaty and peat-boggy soils, tC;

Paris Agreement: an agreement adopted at the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change on December 12, 2015, in Paris and signed on April 22, 2016;

greenhouse gases: gaseous atmospheric constituents of natural or anthropogenic origin that absorb and re-emit infrared radiation. They are assumed to cause global greenhouse effect;

greenhouse effect: increase in temperature of lower atmosphere layers as compared to the effective temperature, i.e., temperature of planet's heat radiation as detected from space;

ripening stand: forest stand with the age class which precedes the maturity age;

carbon pool: carbon amount that is fixed by forest or its components during the "sink-emission" process of carbon dioxide, tC or tCO_2 equivalent;

soil carbon sequestration by forests: the process of organic carbon withdrawal from small biological cycle by forests to enable its long-term preservation as humus or peat;

mature stand: forest stand which has reached the maturity age;

average carbon sequestration: carbon amount fixed by one hectare of forest fund or its components (phytomass, dead phytomass, soil, etc.), tC/ha;

average change of carbon sequestration by forest: difference of average carbon sequestration between the current and the previous years, tC/ha/year;

CO_2 sink (absorption): carbon dioxide absorption from the atmosphere during photosynthesis of green plants, including forest vegetation, tCO_2;

total forest carbon: total carbon amount in forest, tC;

forest dead phytomass carbon: carbon content in forest floor, dead-standing trees, windfallen trees, dead/ fallen branches, roots and stumps under storey and forest live cover in the forest lands, tC;

phytomass carbon of forest fund: carbon content in the overground and underground phytomass of forest fund, tC;

CO_2 quota: highly regulated means of payment used to compensate or neutralize CO_2 emissions. One CO_2 quota gives the right to one-ton carbon dioxide emission or equivalent amount of another greenhouse gas;

carbon credit: all types of greenhouse gas emission reduction as a result of project solutions. 1 carbon credit = 1 ton of carbon dioxide emissions;

conditionally-mobile organic carbon in forest: carbon amount in the 0–10-cm soil layer of forest lands;

conditionally-stable organic carbon in forest: carbon amount in the 10–30-cm soil layer of forest lands;

overground phytomass of forest: total amount of live organic vegetative substance accumulated by a forest stand, young growth and understorey as well as by the live ground cover of forest and non-forest lands of the forest fund;

underground phytomass of forest: total amount of live organic vegetative substance accumulated by roots, underground stems, nodules, bulbs, etc. of trees of young growth and understorey as well as of the live ground cover of forest and non-forest lands of the forest fund.

EXECUTIVE SUMMARY

The present publication within the Belarus Forestry Management Project (TFOA1173 GEF/WORLD BANK) contains strategy of the balanced ecological and socio-economic forest management in the context of weather and climate change. The publication has been prepared by the scientists of the educational institution "Belarusian State Technological University". The ordering organization of the consultancy services for development of forest management strategies and action plans is the Ministry of Forestry of the Republic of Belarus.

The first chapter of the publication provides ***reasons of the observed environmental concerns*** – the stable temperature rise, deviation of annual precipitation dynamics on the territory of Belarus from the climate normals. The stable functioning of the forest ecosystem, positive dynamics in enhancing the country's forest resources over the last seven decades are becoming vulnerable due to current weather and climate changes.

The crucial *role of Belarusian forests in maintaining favourable living environment and in the country's economy* is becoming an important component of the national forest policy. The concept and goal of climate-oriented development of forestry are also described in the publication. They envisage addressing the following major issues:

– adaptation of forestry to climate change;

– increase of carbon dioxide absorption by the forest fund;

– introduction of the principles of the "green economy" in the forestry of the Republic;

– enhancing contribution of the forest sector to climate stabilization.

The publication illustrates the contribution of *the World Bank, the Global Environment Facility* and other international financial and environmental organizations into development of the forest sector of the Republic of Belarus. The major governmental decisions which determine basic principles and directions for development of forestry of the Republic of Belarus with low greenhouse gas emissions are indicated in the book.

In Chapter 2 ***conceptual approaches to forest management in Belarus in the context of weather and climate changes*** are formulated.

Adaptation of forestry to climate change is performed on the basis of:

– new boundaries of agro-climatic regions;

– updating species composition and stands' structure during reforestation and afforestation;

– searching ways for increasing the forest cover in the Republic;

– introducing new methods of forest management, enhancing non-clear commercial cuttings, increasing the share of the natural forest regeneration;

– developing selection seed production in forestry, using genetic potential during adaptation activities;

– improving methods and technologies of forests' security and protection taking into account climate change, organizational arrangements and management activities in the forestry of Belarus.

In order *to maintain the achieved high level of annual carbon dioxide absorption* by the forest fund of the Republic of Belarus, under the conditions of increment of mature forests and simultaneous increase in wood harvest it is recommended:

– to specify the Mission of the Forest Sector of the Republic of Belarus and Responsible Forest Management Indicators in order to realize the Global Forest Goal 1, set by the UN, as related to its part "The world's forest carbon stocks are maintained or enhanced" and commitments under the Paris Agreement;

– to implement the set of measures envisaged by the developed National Action Plan on increasing the level of carbon dioxide absorption by the forest fund of the Republic of Belarus;

– to enhance activities on improving the productivity of forests as a key action for increasing the atmospheric carbon "stock" in forests. The document provides the list of activities and their usefulness for increasing carbon sequestration capacity of forests;

– to improve the institutional framework of carbon sequestration by forests, including the regulatory and legal framework, monitoring of carbon flows in forests, forest inventory planning, etc.

Introducing *the principles and criteria of a "green economy" in the forestry* of Belarus is based on the methodological approaches in international and national practice, in particular:

– basic principles of sustainable development, nature and forest management;

– provisions of the Paris Agreement;

– "green" economy principles, etc.

The following basic "green economy" principles have been justified and defined for the forest sector of the Republic of Belarus:

– the resource-efficient and sustainable use of forest resources;

– conservation, protection, development and adaptation of forests to climate change and increasing their contribution into greenhouse gases absorption;

– strong social policy and high standard of living due to development of forest sector and forest management;

– enhanced international prestige of the Republic of Belarus as a "green country";

– development of forest ecological services.

The document describes the concept of *the climate-oriented forestry development strategy* which includes:

– increment of timber stock;

– sustainable production of forest fund ecosystems;

– intensified and efficient GHG sequestration and emission processes based on rational forest management.

Forestry is considered to be a climate stabilization factor and is acquiring political significance in this regard. The climate-oriented forest policy outlines the following:

– international environmental significance of the forests of a certain state;

– strengthening the country's position as concerns the forestry actions related to climate change;

– establishment of a new role and historical place of the country in the solution of global environmental problems.

Realization of climate – oriented forest policy causes formation of adequate forest management.

In Chapters 3 and 4 the working mechanisms and activities on implementation of the prepared ***Strategy and National Action Plan for Forestry Adaptation to Climate Change*** are reflected**.**

It is envisaged to achieve by 2050 the following major results in *combating adverse climate change effects*:

– the forest cover of the territory of Belarus is to be enhanced up to 42%;

– the share of mixed forest plantations, created during reforestation, is to reach up to 77%, with the share of hardwood species of 6,5%, the share of natural regeneration of 50% , the share of forest cultures created with selection planting material – of 50%;

– the early forest fire detection system based on remote methods is to cover 95% of the forest fund area;

– the area of forest-pathological surveys is to increase up to 3 mln. ha per year, biological methods of forest protection are to be carried out on an area of at least 100 thou ha per year;

– other achievements.

Activities of the National Action Plan for Adaptation of Forestry to Climate Change *are broken down* by forest fund holders according to *agro-climatic zones* and are subdivided into 5-year stages till 2030.

The activities (25 in total) are clustered into 5 groups according to the focus areas:

– the monitoring system of the state of forests;

– improvement of technologies and methods of forest felling;

– improvement of approaches, technologies and methods of reforestation and afforestation;

– preservation of the genetic potential of forests;

– increase at the genetic level of the adaptive capacity of forest stands to climate change;

– improving methods and technologies of forests' security and protection taking into account the climate change in Belarus.

Chapter 5 focuses on the National ***Action Plan on Increasing the Absorption of Greenhouse Gases*** by Sinks (Forests, Swamps) until 2030.

The document examines the crucial *role of the Belarusian forests as a carbon dioxide sink* – 7740 mln. t CO_2 have been sequestered over the period 1956-–2017. It is noted that this is the result of responsible forestry activities, rational wood harvest volumes and other factors. The positive feature is the predominance of the storage form of carbon cycle. 61,3% of carbon sequestered by the forests of Belarus (3,49 bln. tC) is stored in soil and 7,6% is a "conditionally stable" form of the biological cycle.

Carbon balance ("sequestration-emission") of the forest fund is not time-stable due to the dynamics of wood stock and the level of forest utilization. The forecasted *increase in the wood harvest volume* in the forests of Belarus will lead to additional "*emission" of carbon dioxide over 2018–2030 in the amount of 23.9 mln. tCO_2*. For the longer term (appr. till 2075), it is forecasted that optimum age structure of forests in Belarus will be reached (the so-called "normal forest") and timber will be harvested in the volume of allowable cut for uniform forest use. In this case wood "removal" will approach the volume of current increment.

The natural annual carbon dioxide absorption approaches its "emission" from the "removal" of the harvested timber. The annual absorption (46986 thou. t CO_2 per year in 2017) may decrease to 8995 thou. t CO_2 per year by the second half of the XXI century.

Maintaining the achieved annual absorption level of 2017 is becoming a strategic task of forestry sector. This can be possible in case of carrying out specific *compensatory measures on increasing carbon dioxide absorption by forests*. The mentioned in Cahpter 5 National plan contains a list of efficient forestry activities (11 in total). The forestry activities are supplemented by activities (a total of 7) on improvement of institutional framework as concerns carbon dioxide absorption by the forest fund of Belarus. These are strategic directions of further enhancing of the forestry role in the area of climate change in the XXI century.

The activities of the National Action Plan o*n increasing the level of carbon dioxide absorption by the forest fund* of the Republic of Belarus and their scope by public forest management bodies, expected results and other information are combined in four tables (5.4–5.7) in the publication. The calculation of increasing the absorption of carbon dioxide from the target activities is contained in Table 5.8.

The contribution of specific activities into the compensation of the expected carbon dioxide "emission" from the increase in wood harvest in the forest fund of Belarus is estimated as follows;

– increase of average density of stands – 30%;

– use of logging residues from commercial and other cuts for energy purposes – 23%;

– the same during litter collection – 20%;

– change of forest management regime in swampy forests into conservation regime - 10%;

– long-term exclusion of certain forest areas from felling – 9.2%;

– non-clear commercial cuttings – 3.2%;

– creation of forest plantations by closed root nursery stock – 2.8%;

– restoration of low-value forest stands – 2.5%.

Chapter 6 is dedicated to actions on ***introduction of the principles of the "green economy" in the forestry*** of the Republic of Belarus.

The major tendencies in development of the "green economy" in the forest sector, the applied principles and criteria are addressed and examined in detail earlier in Chapter 2 of the publication.

Implementation of the developed activities on introduction of the "green economy" principles into forestry includes *the scope of activities,*

the timing (2018–2025 and 2026–2030) *and the responsible executors*. The activities have been agreed with all the public forest management bodies.

By 2030 the following *major indices are planned to be achieved*:

– the volume of timber logging by harvesters during clear cuttings will reach 75 % of the total volume of cuttings by 2025 and 80% – by 2030;

– the use of low-value firewood in the Republic for energy purposes will amount to 53471 thou. m^3 over the period 2018–2025 and 34845 thou. m^3 over the period 2026–2030;

– energy uses of logging waste from commercial and other cuttings will enhance;

– annually about 100 km of forest roads will be constructed;

– promotion of natural forest regeneration will be provided in mature stands on the area of 27840 ha over the period 2018–2025 and 26740 ha over the period 2026–2030;

– the average density of stands will increase by 0.016 by 2025 and by 0.044 by 2030 as compared to 2017;

– the forest management regime in swampy forests will be changed to conservation regime on the area of 220.0 thou. ha over the period 2018–2025 and 238.6 thou. over the period 2026–2030;

– forest areas monitored by remote early fire detection systems will increase and will amount to 40% of the total forest fund area by 2025 and 50% by 2030;

– the forest-pathological surveys of the forest fund, including the remote sensing methods, will be conducted on the area of at least 1500 thou. ha over the period 2018–2025 and at least 2000 thou. ha over the period 2026–2030;

– additional workplaces will be created in the "green economy" sector of the Republic of Belarus as a result of marketing, promotion and development of tourism services rendered on the basis of forestry institutions.

Chapter 7 describes the developed ***Long-Term Forestry Development Strategy*** of the Republic of Belarus ***with Low Greenhouse Gas Emissions*** until 2050.

It is stated that a *high-technology economy of the forest complex* is currently being formed in the Republic of Belarus which is indicated by market prices for wood raw materials. According to the National Strategy for Sustainable Development until 2030, the forestry economy

is expected to double over the period from 2016 to 2030. This tendency should remain stable in a more distant future.

The principles of a “green economy” envisage the following directions for the development of forestry:

- Ensuring sustainable production and consumption of “green” ecological products based on certification, labeling, innovation, use of life cycle assessment tools, green building standards, etc.
- Definition and assessment of forest functions, establishment of fees for ecosystem services. Payment for the forest ecosystem services: moving from theory to practice; in particular, increasing payments for ecosystem services at the national level and developing guidelines and tools that will serve as the basis for paying for ecosystem services and justifying potential financing options.
- Creation of “green” jobs. Employment and stable wages for the people living in small towns and rural areas. Consideration and discussion of the main threats to the sustainability of the workforce and possible countermeasures at the political level, the development of tripartite (government-trade union-employer) approaches to “green” jobs in forestry using such tools as instructions, minimum standards, increased investment in education and professional training of contractors and forestry workers. Improvement of the system for monitoring of occupational safety and health of forestry workers, ensuring relevant legal compliance as well as rules development taking into account changes in technology and social conditions. Financing of the professional development programs in occupational safety and health for the employers and employees.
- Forest management for sustainable development, including the rural areas. Promotion of sustainable management of forestry in rural areas (entrepreneurship, capacity building and innovation) by means of regulatory and legal framework enhancement. Introduction of management systems in forestry that would be effective, efficient, less bureaucratic and more transparent. Improvement of interaction between branches of power of various levels and the public. Improvement of reporting about all aspects of the forest sector and policy building based on objective analysis of good data. Informing, raising awareness, ensuring participation of concerned parties in interdepartmental processes and initiatives related to “green economy” and integrating the module "forests and green economy" into educational programs.

As a result of implementation of the Long-term Forestry Development Strategy of the Republic of Belarus with Low Greenhouse Gas Emissions for the period up to 2050, the following will be provided:

– ecological conditions for the long-term forestry development of the Republic of Belarus, which regulate the processes of absorption and emission of greenhouse gases based on the superiority of annual growth over the annual forest use;

– socio-economic conditions of low-carbon forestry development on the basis of further strengthening the legal status of a forestry as an institution with the allocation of self-sufficient entrepreneurial structures, and generally, with an orientation to rental income with a favourable pricing policy in the forest sector;

– mechanisms of climate-oriented development of forestry, among which are:

– Institutional (forest policy, forest cadastre, forest monitoring;

– Assessment (a system of indicators of the effectiveness of low-carbon forestry development);

– Economic – rental "green" economy.

The ***Conclusion*** summarizes the results of the provided consultancy service. It also contains recommendations for adaptation of forestry to climate change, maintaining the high carbon sequestration level in the forests of Belarus, introduction of the "green economy" and climate-oriented principles for development of forestry with low greenhouse gas emissions.

Annex 1 contains brief summary of the Terms of Reference of Activity 3.1.4. under Contract № BFDP/GEF/CQS/16/25-26/17 as of October 23, 2017, within the Belarus Forestry Management Project (TFOA1173 GEF/WORLD BANK).

Annex 2 provides information on educational and scientific activities and the human resources of the educational institution "Belarusian State Technological University" (BSTU) – the Consultant under Activity 3.1.4.

BSTU is a leading higher educational establishment of the Republic of Belarus and the CIS in the forest, chemical and printing production sectors.

1. INTRODUCTION

1.1. Climate Change and Forestry of the Republic of Belarus

Among global environmental concerns the effects of climate change have the most significant impact on sustainable development of the humankind. The last quarter of the twentieth century and current years of the twenty-first century have been marked by sharp warming. This process is mainly affected by changes in the composition of the atmosphere and by a significant increase in the amount of greenhouse gases (GHG).

This causes necessity to elaborate and adopt at the national level various preventive measures on adaptation of environment to climate change. Thus, climate researchers have noted that in Belarus over the past 20 years the average annual temperature rise has been recorded which exceeds the climatic threshold by 1.1°C [1]. Moreover, the recent warming period is characterized by a noticeable higher inter- and intra-annual irregularity in precipitation. The changes in precipitation and the temperature regime lead to droughts which have also become more frequent over the past 20 years. According to the estimates for the next 60 years it is expected that on the territory of the Republic of Belarus the average annual temperature will continue to rise by 1.0–2.9°C more [1]. Moreover, it is forecasted that the increase of the average annual precipitation will be negligible and will occur mostly in winter months when its role as a source of moisture for vegetation for the current year is not significant.

Belarusian forests play a crucial role in maintaining favorable living environment, provision of stable functioning of the state's forest sector, substantially contribute to meeting requirements of global environmental conventions acceded to by Belarus.

The efficient forest management activities provide for positive dynamics in enhancing forest resources. Over the post-war period (1945–2018) the productivity of forests has increased by 3.1 times (the average stock of stands +147 m^3/ha) and the total stock increased by 5.6 times ((+1474.8 million m^3). The area of mature and overmature stands reached 14.7% which almost meets the norm for optimum age structure of forests. In perspective, the principles of sustainable forest management will allow

to substantially increase the volumes of timber procured within the final fellings. Through this the state's forest sector will be consistently provided with timber material for mechanical and chemical processing.

The strategic goal of sustainable forest management is to preserve the ecological function of forests in the context of unavoidable forest harvesting. By demonstrating multi-purpose forest management, the Belarusian forestry is strategically building an ecologically oriented forest policy, which is described in the data below.

At present a steady tendency of reduction of productive forests' area is being observed: the exploitable wooded lands occupy 79.4% (2018) against 92.0% (1945). The share of Belarusian forests allocated for protection of soil and water resources exceeds almost twice the share of the similar European forests [2]. In line with classification of protected forest areas established by the 6th Ministerial Conference on the Protection of Forests in Europe (MCPFE, Oslo, 2011) the overall situation is as follows (in percentage of the total forest fund area) [3]:

- biodiversity conservation (classes 1.1–1.3 of MCPFE) equals to 10.5%, in Europe, excluding Russia, it is 9.0%;
- landscape protection (class 2 of MCPFE) is 19.4%, in Europe it is 18%.

Over two million hectares of forests are composed of nucleus zones, ecological corridors and other components of the National ecological network of the Republic of Belarus (65.04% of the total area of the network).

In recent years forestry has become one of the most vulnerable economic sectors due to current weather and climate changes. Gradual rise of air temperature during the last three-four decades is changing the borders of agro-climatic zones. This will lead to changes in species structure of Belarusian forests.

Currently the risk of windbreaks and windfalls is increasing which leads to spread of forest diseases and pests, appearance of new, more aggressive forms. The amount of fire risk days is growing. Eventually, decrease in forest resistance is observed.

The current negative dynamics of weather and climate impacts on the forest ecosystem is highly stressful for the forest sector in Belarus (large-scale drying-out of forests). Together with the increased volumes of timber harvesting this may influence the carbon balance of woods. Over the past six decades the forests of Belarus have sequestered about 8 billion tons of atmospheric carbon dioxide. Without significant

investments into the carbon sequestering service of the Belarusian forestry it will be impossible to maintain the current annual carbon absorption by forests which compensates for 40% of industrial CO_2 emission in the country.

The Republic of Belarus has been a party to the United Nations Framework Convention on Climate Change since 2005. The country is implementing international commitments such as preparation of climate policy, development of national communications on climate change issues, annual development of greenhouse gas cadastres, performing climate observations and scientific research. Implementation of the state policy in the field of forest management, including adaptation of forestry to climate change, is provided by the Ministry of Forestry.

In Belarus a National Framework Action Plan for Development of a "Green Economy" until 2020 has been developed and approved by the Government on December 21, 2016. Still in this document the activities on introduction of the "green economy" into forestry are not presented in full scope. The commitments of the Republic of Belarus to the Paris agreement envisage a set of activities on mitigation of climate change and adaptation of the economy sector to the changing natural factors. Forestry plays an important role in this issue. In view of the above it is required to update appropriately the program documents already developed and being implemented now, to make correspondent modifications and amendments to them, taking into account the dynamically developing world's economy and the changing natural climatic factors.

For further sustainable development of the country it is required to develop the "green economy" principles applicable to the forestry of the Republic of Belarus, as well as to substantiate the criteria and activities for their implementation with account of the international expertise, national practices in forestry and forest management as well as legal and regulatory framework.

In order to avoid the climate change consequences it is of primary importance to decrease the level of greenhouse gases in the atmosphere. And only restoration of area of woodlands can help with this. Unfortunately, since 1995 till present the total area of forests on the planet has decreased by 3% [4]. The World Bank with the participation of the Small Grants Programme of the Global Environment Facility supports efforts of climate change mitigation, including prevention of deforestation, facilitates enhancing afforestation, reforestation and general contribution of forests to sustainable development since 1995 till present.

The increased requirements for forest management must respond to modern, social, environmental and economic standards. Creation of an ecological and economic forestry system focused on increment of wood resources and sustainable production of forest fund ecosystems, on intensified and efficient GHG sequestration and emission processes based on rational forest management will require elaboration of a climate-oriented concept within the strategy of forestry development in Belarus.

A specific forest policy should be developed due to necessity of more consistent linkages between the forest ecosystems' processes of absorption and emission (volumes of biomass increment and share of its usage as a result of forest management).

Climate-oriented forestry development envisages addressing two major concerns:

1. Adaptation of forestry to climate change.
2. Enhancing forestry contribution to climate stabilization.

These issues are inter-connected, the second issue can be considered within the first one (as a process and an adaptation component).

From the point of view of system analysis and strategic decision-making consideration of forestry as a climate stabilizing factor acquires political significance. Climate-oriented forest policy is a policy expressing international ecological value of the woods of a certain state and providing their sustainable reproduction under conditions of climate change instability and increase of environmental risks. The climate-oriented forest policy is not just strengthening of the country's position concerning the forestry's response to climate change. It also means emerging of a new historical role of the country in addressing global environmental concerns. Moving forward in this direction cannot be successful without international consensus and involvement, including financial and economic aspects.

1.2. Cooperation with International Financial and Environmental Organizations and Programs in Developing the Forest Sector of the Republic of Belarus

An example of long-term strategic cooperation of the World Bank and the Global Environment Facility with the Government of the Republic of Belarus on sustainable forest management is the new

Belarus Forestry Development Project (2015). The Republic of Belarus is one of the most forested countries in Europe and Central Asia. This project is the second project in the forest sector of the Republic of Belarus, funded by the World Bank.

The first project on forestry development, implemented from 1994 to 2002, was in fact the first investment project of the World Bank in Belarus. With the funds of the World Bank an information system for forest management, a system for monitoring forests and radioactively contaminated lands and wetlands were introduced, modern equipment for forest cultivation and timber harvesting was procured, a forest selection and seed-growing center was equipped, educational programs were implemented on the basis of Belarusian State Technological University (BSTU) and the branch training center, the material base of forest scientific and educational institutions was strengthened.

One of the components of this project is the Strategic Plan for the Development of the Forestry Sector of the Republic of Belarus for the period from 1997 to 2015. In the past, the most significant strategic planning document was the Master Plan for the Development of Forestry in the Byelorussian SSR, drawn up in 1959 and scheduled up to 1975. This policy document determined the conditions and pace of forestry development for 17 years. The Strategic Plan for the Development of the Forestry Sector of Belarus adopted in 1997 differed from all the previous policy documents by encompassing a wider scope of forestry challenges. It affected improvement of ownership forms and management in the sector, solution of economic tasks, development of education and forest science, technical development of forestry and introduction of advanced technologies, optimization of human resources, the issues of developing a new forest policy and legislation. Special emphasis was placed on issues of forest ecology as the basis for stabilizing the human environment and other organisms' habitats, complicated by radiation contamination of the territory, problems of forest drainage, exposure to fire damage, pests and diseases, and other negative anthropogenic impacts on the forest ecosystem of the republic.

Afterwards with the support of the EC, the World Bank in partnership with WWF and IUCN implemented regional Program on "The European Neighborhood and Partnership Instrument East Countries Forest Law Enforcement and Governance II Program" during two phases (2008–2011, 2013–2016). One of the activities of the program was development of the Strategic Plan for the Development of the

Forestry Sector of Belarus for the period from 2015 to 2030. It was approved by the Deputy Prime Minister of the Republic of Belarus Mr. M.I. Rusyi on December 23, 2014 (No. 06/201-271) and fully conforms to the provisions of the new Forest Code (2016). The activities planned to be realized can be considered as new tasks and approaches to forest management in Belarus.

The objectives of the Belarus Forestry Development Project include improving efficiency of forestry activities, reforestation and afforestation, increase in the use of felling wastes and enhancing contribution of forests to the achievement of public goods in the target forest areas.

In Belarus much effort has been taken to adopt the methods for organizing and conducting ecologically oriented forestry as a basis for the sustainable forest management and utulization. Thus, silvicultural systems have been developed for the formation of native forest stands based on soil and forest typology, with the use of non-clear forest cuttings, recreational forestry, forest management in water protection areas and under conditions of intensive pollution of the natural environment. With the participation of the United Nations Development Programme, the Global Environment Facility and the Royal Society for the Protection of Birds (United Kingdom), measures have been prepared for the greening of reforestation, intermediate and final fellings, etc. The concept of ecological networks on the forest area and in landscape planning in sustainable forestry has been proposed. A pilot project on sustainable forest management based on the Smorgon experimental forest enterprise has been accomplished. Belarus is participating in the implementation of the EU-funded international project "Baltic Landscape in Change – Innovative Approaches towards Sustainable Forested Landscapes". In this long-term 12-year project seven countries and 15 partners take part, with the Swedish University of Agricultural Sciences as the leading one among them. Within the project the model forest concept is used. The project objectives are achieved through the creation of a network of eight model Baltic landscapes in four countries (Belarus, Finland, Poland, Sweden). As a result of the project activities within 2011–2014, the concept of creating a model Baltic landscape based on the Novogrudok forest enterprise has been prepared. The mentioned pilot projects should promote large-scale introduction of environmental planning in the forestry sector of Belarus.

Meanwhile, the previously developed strategies and programs need to be updated in terms of adaptation to the changing natural

factors, primarily weather and climate, strengthening the role of forestry in climate change mitigation, introducing the principles of a "green economy" in forestry.

Consequently, it is required to formulate an updated strategy for development of the existing ecologically oriented forestry in the conditions of the observed climate change.

In view of this within the framework of the Belarus Forestry Development Project the GEF/World Bank have initiated implementing of Component 3: Building the Capacity for Sustainable Forest Management, including development of Activity 3.1.4: Consultancy Services to Develop Strategies and Actions Plans for the Adaptation of the Belarusian Forestry Sector to Climate Change and to Implement the Principles of "Green Economy".

The strategies and plans prepared by the Belarusian State Technological University (hereinafter BSTU) within Activity 3.1.4 are presented in this brochure as the Ecologically Oriented Strategy for the Development of Belarusian Forestry in the Context of Climate Change (hereinafter the Strategy).

The strategy is founded on the hypothesis of formation of a low-carbon forest management system. The key provision of the Strategy is: carbon weight sequestered by the annually harvested timber shall not exceed the annual carbon absorption by the forest fund stands. The low level of greenhouse gas emissions is provided by sustainable forest management.

Low-carbon forestry is aimed at achievement of sustainable, economically efficient, environmentally responsible and socially oriented forest management and utilization. The economic efficiency implies an increase in the profitability of forest management. Environmental responsibility ensures the achievement of environmental goals, including climate-oriented development. The social focus of forest management and utilization provides public goods and ecosystem services, increase in the well-being of the population.

The main principles and areas of focus in the development of the forestry with low GHG emissions in the Republic of Belarus are determined by the following documents:

– Decree of the President of the Republic of Belarus No.345 dated September 20, 2016, "On adoption of International Agreement";

– The State Program on Climate Change Mitigation Measures for 2013-2020. (Resolution of the Council of Ministers of the Republic of Belarus No. 510 dated June 21, 2013);

– The National Strategy for the Conservation and Sustainable Use of Biological Diversity (Resolution of the Council of Ministers of the Republic of Belarus No.743 dated September 3, 2015);

– The National Action Plan for the Development of a "Green Economy" until 2020 (Resolution of the Council of Ministers of the Republic of Belarus No.1061 dated December 21, 2016);

– The National Strategy for the Sustainable Social and Economic Development of the Republic of Belarus for the period until 2030 (Minutes of the meeting of the Presidium of the Council of Ministers of the Republic of Belarus No.10 dated May 2, 2017);

– The Strategic Plan for the Development of the Forestry Sector for the period from 2015 to 2030 (approved by the Deputy Prime Minister of the Republic of Belarus Mr. M. I. Rusyi, No. 06/201-271 dated December 23, 2014);

– The State Program "Belarusian Forest" for 2016–2020 (Resolution of the Council of Ministers of the Republic of Belarus No.215 dated March 3, 2016).

2. CONCEPTUAL APPROACHES TO FOREST MANAGEMENT IN BELARUS IN THE CONTEXT OF CLIMATE CHANGE

2.1. Adaptation of Forestry to Climate Change

In the context of the ongoing climate change forestry is considered as one of the most vulnerable sectors of the economy, requiring special measures to minimize the damage.

The main areas of focus of forestry adaptation to climate change in the European countries are the increase in the proportion of forests, maximum possible conservation of their genetic diversity, application of natural regeneration in reforestation, revision of maturity of stands and timing of thinnings, creation of mixed uneven-aged plantations, work on introduction of tree species most adaptable to the climate change [9, 26, 27, 28, 29].

The climate of the Republic of Belarus has changed considerably which caused significant impact on the state of forests.

Over the last three or four decades a gradual increase in air temperature has been observed on the territory of Belarus. The stable temperature rise began in 1988. On average from 1988 to 2015 the air temperature exceeded the norm by 1.3°C (Figure 2.1).

In some years (1999, 2000 and 2002), the average annual temperature was 2°C above the normal. The feature of air temperature change in Belarus is its significant increase in January and February (almost by 4°C) and in March and April (by 2°C). As a result, December is the coldest month of the year. Such significant and durable temperature anomalies have not been observed for the whole time of instrumental temperature record. In summer months (June–August), quite small positive temperature anomalies of 0.1–0.6°C are witnessed. The positive temperature anomalies in March-April favor the early descent of snow cover and the 0°C temperature surpass two to three weeks earlier than usual [5, 6].

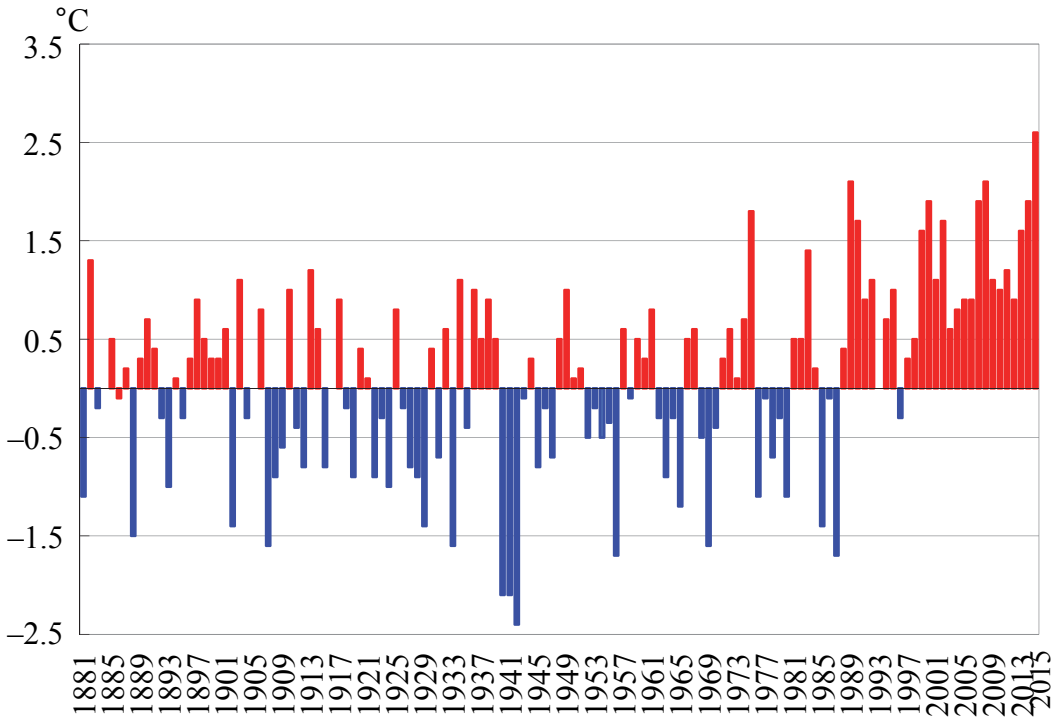

Figure 2.1. Deviation of average annual air temperature in Belarus from the climate normal (+5,8 C) over the period 1881-2015 (ºC) [5]

In response to the changing climatic conditions, the species that are at the edge of their geographical range in Belarus (*Pícea ábies*, *Cárpinus bétulus*, *Álnus incána*) will change their distribution. This will be caused by the fact that at the edge of the geographic range these species live in harsh conditions as concerns temperature regime and dry climate.

Changes of the boundaries of agro-climatic regions will later lead to the change in the species composition of the forests of Belarus (Figure 2.2). Boreal species such as *Pícea ábies*, *Álnus incána*, possibly *Pínus sylvestris*, as well as moisture-loving species ((*Fráxinus excélsior* and *Álnus glutinósa*) will partially lose their stability, competitiveness and will reduce their share in the forest composition. It is possible that *Pícea ábies* will disappear from the southern regions (Brest and Gomel). In Minsk, Mogilev and Grodno regions, the distribution area of European spruce will be significantly reduced. This may be further exacerbated by the increase in the number and duration of droughts which will cause the outbreaks of mass reproduction of forest pests and, consequently, the death of European spruce stands on large area of these regions. Only in the north-east of the country, where the continental climate is more pronounced, European spruce stands will be preserved [7].

Figure 2.2. Change in distribution ranges of European spruce, Hornbeam, Gray alder [30]

To increase the stability of European spruce forests, it is necessary to create mixed stands. At the same time on rich soils, European spruce should be fully or partially replaced by broad-leaved species (*Quércus róbur*, *Tília cordáta*) and *Lárix decídua*. To preserve European spruce in the composition of forests, it is necessary to reconstruct small-leaf stands and replace them with birch-spruce and aspen-spruce stands. Also, it is necessary to create mixed spruce-pine, spruce-oak and spruce-fir forest cultures. This will allow not only to preserve European spruce but also to increase its share in the composition of forests.

Climate warming will create conditions for increasing the share of broad-leaved forests, in particular, Common oak forests. In Mogilev and Vitebsk regions, their area can be significantly expanded by creating mixed forest cultures on loamy soils. A good companion plant for Common oak is Small-leaved linden. In the tree waste of Small-leaved linden there is a lot of nitrogen, phosphorus, calcium. The lower the fertility of the soil and the worse its physical properties, the greater the positive effect of Small-leaved linden. Bird cherry, elder, hazel and maple also have a high capability to accumulate nutrients reserves in forest litter. Their tree waste gives the largest amount of mineral substances. The presence of Larch in the Common oak forests increases the humidity of the upper layers of the soil, contributes to an increase in the amount of labile phosphorus, potassium.

Due to the climate warming the emergence of *Fágus sylvática* in the forest composition and the wider use of Larch become possible. Adding of European beech in Scots pine and Common oak plantations on sandy-loam soils improves their fertility and promotes the growth of the main species. In Poland, within implementation of the seed progenies testing program [24], trial plantations of this species were laid out to the north of its distribution range (Figure 2.3). The selected south-eastern region in its northern part adjoins the southern part of Brest region. There is also successful experience in the cultivation of European beech in the territory of the Suwalki forestry, which corresponds to the latitude of Logoisk, Borisov and Shklov in Belarus.

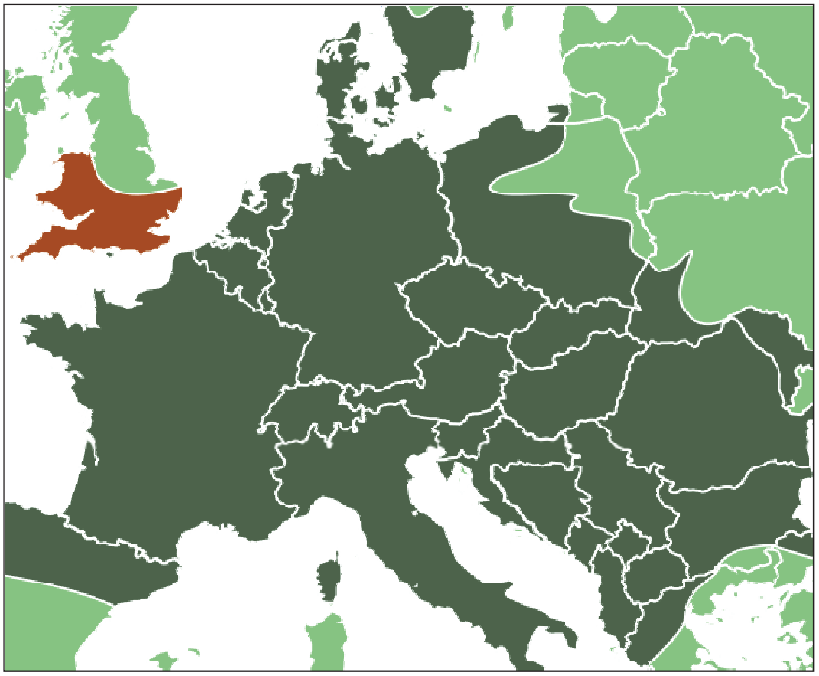

Figure 2.3. Distribution range of European Beech [24]

It is possible that *Ábies álba* stands will expand to the Brest and Gomel regions. The distribution area of this species is located in the Carpathians, Central and Southern Europe (Figure 2.4). The climate change in Belarus causes a northward shift of distribution range of European spruce. This allows to consider *Ábies álba* as one of the variants for creating mixed forest plantations with the use of *Pínus sylvestris*, *Lárix decídua*, *Tília cordáta*.

Quércus pétraea is also of great interest in view of possibility to appear on the territory of Belarus. This species is widely spread

throughout almost the whole Europe. The distribution area passes through the territory of Ukraine practically along the southern border of our Republic. In comparison with *Quércus róbur* this species is more heat-loving and less demanding for fertility and soil moisture. However, its wood is softer.

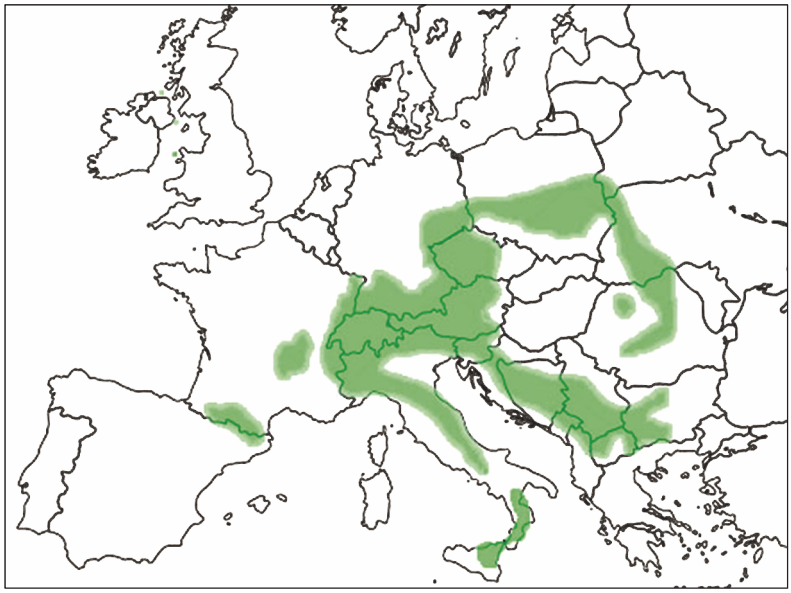

Figure 2.4. Distribution range of *Ábies álba* [25]

With a general positive assessment of forest management in the context of climate change in the Republic of Belarus, it is necessary to introduce and expand technologies and methods aimed at increasing the sustainability of stands while improving their productivity and quality.

In order to mitigate the consequences of climate change, the activities aimed at increase of forest cover must be continuously carried out on the territory of the country, because forests play a decisive role in regulating the temperature regime on the planet as the main carbon dioxide sinks.

As mentioned before, much effort is taken by the Ministry of Forestry to increase the forest cover in the Republic of Belarus. At the beginning of 2017 the forest cover of the territory was 39.8%. However, taking into account tree and shrubbery vegetation which is not included in the forest fund, the area can reach almost 46% [8].

One of the most probable sources of the forest cover increase in the Republic of Belarus, under existing definition of the forest cover, is

the use of low-value agricultural lands transferred to forestry institutions. It is difficult to estimate the amount of such lands and to forecast the annual scope of their transfer, since it is possible only by order of the President of the Republic of Belarus with the participation of the Ministry of Natural Resources, the Ministry of Agriculture and the Ministry of Forestry, and local executive and administrative bodies.

The most substantial increase of the forest cover can be achieved if the area of the tree and shrubby vegetation is included into the calculation of the forest cover area. According to the definition of 'the forest' by the United Nations Framework Convention on Climate Change, most of such plots can be defined as forest areas and perform the climate-regulating function. According to the Register of Land Resources at the beginning of 2017, there was 805.1 thousand ha of such areas. Use of these territories in calculating the forest cover area will result in its 3.89% increase.

One of the ways to extend the forest cover is to increase the proportion of partial cuttings. The increment is achieved in this case due to difference between the areas of clear cutting and the areas introduced into the category of valuable forest stands.

One of the generally recognized postulates of silviculture is the assertion that mixed plants have greater resistance than monocultures. This fair assertion is based on the positive relationship of different species in the mixed plantation, as well as on the assumption that even in case of loss of one species such a plantation will still perform its environment protection functions. Therefore, increasing the proportion of mixed plantations is an effective means of adapting to possible adverse climate changes.

One of effective ways to regulate the structure of a plantation is to conduct pre-commercial thinning, which, as recorded in the Rules of Felling of Forests in the Republic of Belarus, are conducted with the aim of forming mixed and complex plantations. Saving of the secondary species during pre-commercial thinning, especially in young growth, will help to improve the situation with the creation of pure forest stands.

In the process of growing of stands, as well as during felling, it is important to take advantage of the potential for natural regeneration and to implement measures fostering its growing and maintenance. For this purpose it is necessary to improve forest felling technologies which envisage efficient use of the natural regeneration of forests during

reforestation; to increase the share of clear commercial cuts with preservation of undergrowth. It is required to update the technologies and techniques of forestry process with due regard of the best practices of the countries with highly developed forestry and timber industry, which allow to minimize impacts on the forest environment and foster natural forest regeneration.

While designing forest cultivation activities, it is necessary to give preference to methods of natural regeneration of forests. If for any reason natural emergence of forest is impossible or difficult on the whole plot area, a combined reforestation method should be used. It comprises measures on promotion of natural regeneration by mineralizing the soil on the entire plot area, followed by sowing seeds or planting the main plant species in places where natural renewal is impossible or difficult. Seed and planting material should be obtained from stable and highly productive local populations. Afterwards it will be necessary to form mixed stands on these plots.

One of the measures to increase the sustainability of forest stands during climate change is the application of combined forest regeneration methods through the production of partial forest cultures. The partial forest cultures are created in combination with natural regeneration of the forest. In forestry, there are two main ways of producing partial forest cultures: 'strip' planting and 'group' planting. Under the strip method a partial removal of undesirable species is carried out in strips in order to free the space for the introduced species. Under the group method the forest cultures are produced in plots with an insufficient number of conifers and hardwood species. To improve this focus area in production of forest cultures, it is necessary to amend the existing technical regulatory legal acts. It is required to insert additions which contain description of the technology for creation of partial forest cultures, indication of the used planting material. It is also needed to specify issues of technical acceptance, inventory and conversion of partial forest cultures into forested areas.

Climate change has a significant impact on the species composition of forest plantations. In Belarus the change in the distribution range of particular species is already underway. The most significant processes are observed in *Pícea ábies*, whose distribution range' southern border is being shifted to the north. Changes in the temperature regime, the amount of precipitation, lowering of the level of groundwater lead to a periodic drying out of this species. This raises a question of

replacement of spruce with other tree species in the spruce's typical conditions, especially in the southern and central parts of the Republic. In the regions which are currently slightly affected by negative climate change processes it is advisable to create mixed forest plantations of *Pícea ábies*, as well as to form mixed stands during pre-commercial fellings.

The following hardwood species are of great importance for forestry: *Quércus róbur*, *Fráxinus excélsior*, *Ácer platanoídes* и *Fágus sylvática*. The Ministry of Forestry has set a course for gradual increase in the share of hardwood species. The Strategic Plan for the Development of Forestry for the Period until 2030 provides for an increase in the share of hard-wooded broad-leaved species up to 5.5%, among which 4.7% should be formed by oak.

In order to increase the share of hardwood species it is expedient to increase the volume of growing and usage of planting material of other kind for creation of forest cultures. Herewith it should be noted that there is almost no seed resources of *Ácer platanoídes* and *Fráxinus excélsior*. Only 19 plus trees of Ash are allocated, however, this species is drying up massively. Currently the search of the species' forms resistant to canker excitant is underway; therefore development of the seed resources will be possible only after completion of the research. As regards Norway maple, actions should be taken to form the constant seed base. Introduction into sylviplantation of such hard-wood broad-leaved species as *Fágus sylvática* is also of a great interest.

An urgent task is the further improvement of the forest monitoring system for the response to climate change. Such a system will make it possible to obtain data on changes in the distribution areas of species, the appearance of new species, and assess the consequences of climate change on forestry in the Republic.

For testing tree species under new growth conditions, formed under the influence of climate change, it is necessary to create a network of geographical forest cultures. At the same time, attention should be paid not only to local forest-forming species, but also to those species that are possible to use in silvicultural production and also to species, which distribution areas are close to the territory of Belarus.

Taking into account that climate change is characterized by increase of average daily temperature, the necessity may arise to revise the boundaries of modern seed and forest areas. It should also be expected that new more drought-resistant forms may emerge in Belarus and even

plant species, whose distribution areas are now to the south of the border of the Republic of Belarus.

Unfavorable weather conditions represented by changes in the temperature and hydrological regimes, increase the risk of windbreaks and windfalls, contribute to the spread of diseases and forest pests, as well as emergence of new, more aggressive forms, and extend duration of the fire risk period. All these factors finally lead to weakening of forest ecosystems. To solve this problem, it is necessary to strengthen the work on the conservation and use of a valuable gene pool of forests which is mostly adapted to local natural and climatic conditions.

In the forestry of Belarus two approaches to seed management in the process of creation of forests are used: 'plantation' seed management (forest seed plantations of the first and second generations) and 'population' seed management (plus stands, genetic reserves, valuable seed stands, stands of the source-identified selection category). However, at present, the main emphasis is made on the first approach, which involves planning of creation of forest seed plantations based on elite and plus trees. At the same time, application of the second approach includes usage of the best-quality seed stands, which belong to the source-identified category and which envisage no selection of best genotypes in terms of productivity and sustainability, as well as normal stands. The unique gene pool of plus stands, which comprise both productivity and sustainability, is not in demand due to complexity of collection of seed raw material.

Till present great work has been carried out by the country on development of seed breeding that allows forest enterprises to use actively the selected planting material in forestry production for enhancing productivity, quality and sustainability of future plantations. The main source of seeds with valuable hereditary properties are forest seed plantations created on the basis of allocated high quality and elite trees.

One of the main tasks of forest seed production is to preserve the valuable gene pool of forest tree species, which becomes especially important in the context of climate change, because in this case the risk of loss of valuable genotypes of high quality and elite trees will significantly increase. The reasons for high quality trees loss can be different such as fires, windbreaks, windfalls, drying due to change of climatic and hydrological regimes, etc. Preservation of a valuable gene pool of forest tree species is carried out by creating archives of clones of high quality trees.

The important issue of forestry adaptation to climate change is not only preservation of individual genotypes of valuable trees, but also preservation of genetic fund of the whole populations. This is be done by allocating genetic reserves – the plots that perform the functions of preserving the forests' gene pool in natural habitats.

Implementation of activities stipulated by the drafts of the Strategy for Adaptation of Forestry to Climate Change for the period until 2050 and of the National Plan for Adaptation of the Forestry of Belarus to Climate Change for the period 2018–2030 will not only ensure the stable functioning of forest ecosystems in conditions of climate change, but will also have a positive impact on the climate. Activities included in the draft documents address issues of forest monitoring, improvement of forest felling and reforestation techniques, preservation of genetic potential, enhancement of adaptive capacity of forest stands at the genetic level, improvement of methods and technologies for security and protection of forests with account of climate change in Belarus.

In development of drafts of the Strategy for Adaptation of Forestry to Climate Change for the period until 2050 and the National Plan for Adaptation of the Forestry of Belarus to Climate Change for the period 2018–2030 the following specialists took part: staff members of the department of Forest Plantations and Soil Science, associate professors N.I. Yakimov, L.F. Poplavskaya, P.V. Tupik; members of the department of Forest Protection and Wood Science, associate professors V.B. Zvyagintzev, V.A. Yarmolovich.

2.2. Absorption of Greenhouse Gases by the Forest Fund Components

The modern paradigm of human attitude to forests does not consider forests only as a source of timber and other material resources. The habitat-forming function of forests also assumes key value along with their special social and environmental functions in providing a healthy living environment on the planet. In recent years industrial emissions of carbon dioxide, its enhanced concentration in the atmosphere and possible climate change impacts have become global concerns.

Due to opinion of the majority of the humankind, climate change of the recent decades has been caused by increased concentration of greenhouse gases in the atmosphere. Main greenhouse gases that have

destabilizing effect on the atmosphere are carbon dioxide, methane, nitrogen oxide and chlorofluorocarbons. The total amount of greenhouse gases is dominated by carbon dioxide (76%).

The biomass of wood and other components of forest ecosystem of the Republic of Belarus has accumulated considerable amount of carbon. Over 1956–2017 (true and fair record period) the carbon content in Belarusian forests increased by more than 2 billion t. This corresponds to the absorption ("removal") of more than 7 billion t CO_2 from the atmosphere if taken as CO_2 equivalent. Experts estimate that over this period CO_2 weight gain ("emission") in the atmosphere amounted to approx. 420 billion t. The Republic of Belarus, whose population makes only 0.15% of the total world population, has compensated 1.83% of the global emissions over the past seven decades [9]. This is 12 times as effective as a per capita contribution by the global forest ecosystem. The current dynamics of carbon flows in the Belarusian forest fund should be given special attention. In particular, annual carbon dioxide absorption by forest fund areas equals to the compensation of a little less than a half of the industrial greenhouse gas emissions in the Republic of Belarus.

High carbon sequestration capacity of the Belarusian forests results from the increased forest cover in the country, enhanced forest productivity, environmentally sound timber harvesting and other factors. Under the recent conditions of global deforestation, decreasing forested areas and wood reserves in the global forest ecosystem, careful consideration and dissemination of the good practices of Belarusian silviculturists in the field of increasing of forest resources and carbon dioxide "stock" by forests are highly appreciable.

The carbon budget of the Belarusian forest fund may change. The following estimates have been made until 2050 and the second half of the 21st century [10]:

–age structure of forests will change towards a "normal" forest;

–timber harvest volumes may increase;

– the area of old-aged conservation forests will increase, they will approach the biological development age and become sources of carbon dioxide "emission".

In view of the above factors the annual carbon dioxide absorption by the forest fund can decrease to 20-25 million t CO2 per year. This is forecasted for wood harvest volumes up to 60% of the wood increment, which is happening now. When the optimum age structure of forests is

reached (around 2075) it could be possible to move over to allowable cut for uniform forest use. In this case wood "removal" will approach the volume of current increment. The natural annual carbon dioxide absorption becomes equal to its "emission" from the "removal" of the harvested timber. The value of annual carbon dioxide absorption by the forest fund will depend on the scope of compensatory measures on increasing carbon dioxide absorption by forests (Figure 2.5).

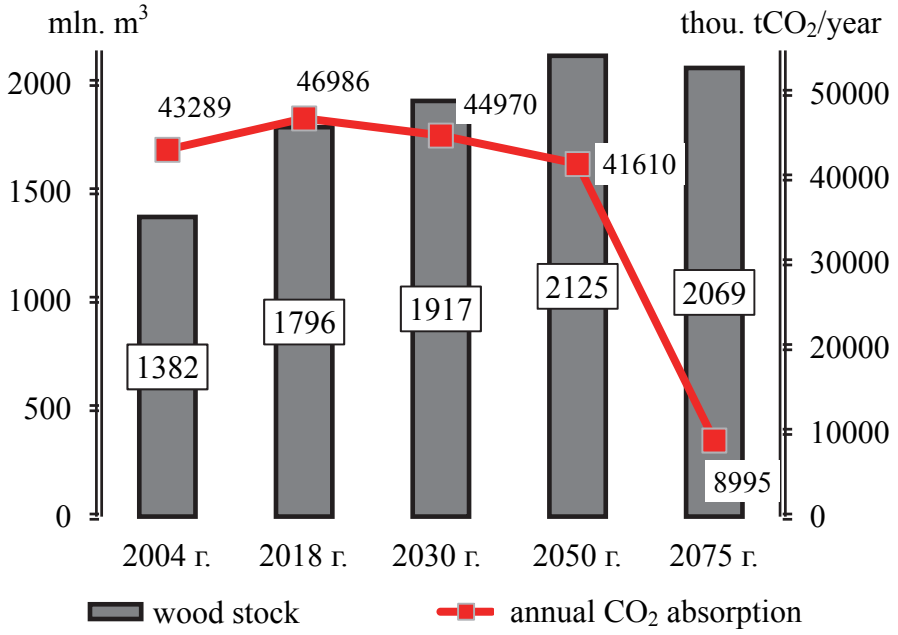

Figure 2.5. Prognosis of wood stock dynamics and annual carbon dioxide absorption by the forest fund of the Republic of Belarus (L.N. Rozhkov)

This trend of the declined carbon dioxide "stock" is contradictory to the national policy of climate change mitigation. Besides, the Republic Belarus has taken several international commitments related hereto.

The way out in this situation is increasing forest productivity and, thereby, the carbon sequestration capacity. The measures to be taken are proposed in the developed National Action Plan on Increasing the Level of Carbon Dioxide Absorption by the Forest Fund of the Republic of Belarus until 2030. Implementation of the activities requires investment. Trading of carbon credits from carbon sequestration by forests can become a source of investment, which is allowed by the Paris Agreement.

Carbon sequestration function of forests is not a free natural carbon absorbing resource. It is a factor of production, and its use value is growing. Carbon uptake is becoming a commodity. In order not to let

the carbon sink resource become a scarcity, significant financial and material investments are required.

The Republic of Belarus is a SFM (Sustainable Forest Management) member, i.e. it has taken commitments for sustainable forest management and achievement of sustainable development goals (SDGs). This particularly relates to target **1.2. The world's forest carbon stocks are maintained or enhanced** under **Global Forest Goal 1** of the six Global Forest Goals specified by ***the United Nations Strategic Plan for Forests*** for 2017–2030 (UNSPF). By Presidential Decree no. 375 dated 20.09.2016 the Republic of Belarus adopted ***the Paris Agreement commitments*** to reduce greenhouse gas emissions.

Therefore an important task of the forest sector in relation to maintaining and enhancing carbon stocks in national forests can be stated as given below. The statement can be regarded as ***the Mission of Forestry of the Republic of Belarus*** to further develop ***sustainable forest management***.

"*Carbon emissions from wood harvested by final felling, regeneration and other cuttings shall be compensated by increasing of carbon dioxide absorption through responsible forest management*".

Responsible forest management must fulfill the following condition:

"*Carbon weight that is sequestered in the annual volume of wood harvest by commercial cuttings, regeneration cuttings, conversion and other fellings shall not exceed the annual absorption of carbon dioxide resulting from the target measures on increasing the carbon sequestration capacity of forests and non-forested lands of the forest fund*".

In order to find the ways of achieving the above targets, Task 2 has been planned within Activity 3.1.4. ("Prepare a National Action Plan on Increasing the Absorption of Greenhouse Gases by Sinks (Forests, Swamps) until 2030").

The aim of Task 2 is ***Creation of the Enabling Environment*** when undertaking the Mission of the forest sector in maintaining and enhancing forest carbon stocks in the Republic of Belarus.

The objectives of Task 2 were:

– to develop working mechanisms for maintaining the achieved carbon budget values in the forest fund of the Republic of Belarus until 2030;

– to recommend to the forest sector efficient economic and other measures on increasing the annual level of carbon dioxide absorption

by forest fund components. This will compensate for 24 million t of carbon dioxide emissions in 2018–2030 due to the planned timber harvest increase from final fellings and other cuts by 22 million m^3 or 41.4% as compared to 2017;

– to prepare a draft National Action Plan on Increasing the Absorption of Greenhouse Gases by Sinks (Forests, Swamps) until 2030 indicating specific measures, their volumes, deadlines for implementation, responsible executors (forest fund holders, State Forestry Production Associations, other parties concerned);

– the strategies, plans, forestry-related and other measures must be scientifically-proven, incorporate advanced international and national practices, take into account the balance of social, ecological and economic interests of the Belarusian society and international commitments of the Republic of Belarus.

The problem of maintaining the level of annual carbon dioxide absorption in the forest fund can be solved by ***increased forest productivity***. The following forestry actions hold a lot of promise:

– creation of forest plantations by closed-root-system seedlings of high selection characteristics;

– reconstruction of low-grade forest stands;

– reducing the cutting cycle for partial cuts by means of conservation of young growth and preliminary assistance to natural reforestation.

Extensive actions on ***increasing the average density*** of stands are also highly promising. In the past this action was given little attention by silviculturists, however it can result in large wood increment by means of improved forest regeneration and forest care.

Swampy forests occupy 18.6% of the total area and provide almost a half of the carbon budget in the Belarusian forest fund [11]. It is important to preserve and ***enhance the carbon sequestration function of swampy forests***. Some swampy forests are managed. With increased forest road construction their timber harvesting role can be expanded. Under intensive increment of upland mature forests it is advisable to reduce cuts in swampy forests. The National Action Plan suggests switching from the forest management to conservation regime of swampy forests that can be very efficient in terms of carbon sequestration, conservation and promotion of biodiversity.

The Strategic Plan for the Development of the Forestry Sector [12] envisages necessity to optimize the age and species structure of the

Belarusian forests. The impact of changes in age and tree species structure of forests in Belarus on the carbon dioxide absorption level has controversial assessments due to necessity of balance of economic and ecological interests. There is also no objective conclusion on the character of changes in the forest ecosystem of Belarus caused by the weather and climate change effects. Our assessment of the results of Task 2 is formulated below [13].

Changes in age structure of forests can be achieved over long (several decades) periods. The ideal age structure of forests, the so-called "normal" forest, and associated uniform forest management ensures only ***half the current level of annual carbon dioxide absorption***. For this reason the optimization of the age structure of forests is considered as not very significant.

It is not necessary to amend the existing program of optimizing the species structure of the Belarusian forests. ***Change of the species structure of the Belarusian forests*** in any proportion of species and with regard to the balance of ecological and economic interests ***will not affect*** the level of annual carbon dioxide absorption by forests.

The enlisted activities constitute a mechanism of the long-term influence on the productivity of forest stands in Belarus. Implementation of the activities allows to forecast the average wood stock of 240 m^3/ha (+10,6% to 2018) and total wood stock of 2069 mln.m^3 (+15,2% to 2018) till 2075. Carbon storage in the forest fund of the Republic of Belarus will increase by 140 mln. tC (+4,0% to 2017).

These and other actions on increasing the level of carbon dioxide absorption by the forest fund call for the improvement of ***institutional framework of carbon sequestration*** by forests which is also included in the suggested measures.

Legal framework for forest carbon sequestration capacity and stabilizing effect on climate and weather changes in Belarus is satisfactory. This is reflected in Presidential Decree No. 345 dated 20.09.2016 with the resolution to adopt the Paris Agreement from 22.04.2016 as well as in the State Program "Environmental Protection and Sustainable Use of Natural Resources" for 2016–2020 and other documents.

It is required to develop certain regulatory acts for the forest sector, to include:

– obligatory ***carbon flow monitoring*** by means of State Forest Cadastre;

– account for carbon sequestration in ***allowable cuts***;

– more detailed carbon sequestration measures in ***forest inventory projects***;

– ***Guidelines for calculation of carbon dioxide absorption and emissions*** in the forest fund of the Republic of Belarus shall be given a status of a regulatory legal act.

About 94% of the suggested actions on increasing the level of carbon dioxide absorption by the forest fund are to be implemented by the Ministry of Forestry as the main forest fund holder. However, the actions should be taken by other forest governance bodies as well. However, other agencies having the right of forest management are also involved in the work. Their involvement in the actions on carbon dioxide absorption is expected to increase in the future.

Forests of the Republic of Belarus render important ***ecosystem services*** at the ***European level***. These services include carbon sequestration and ecosystem protection services. Unfortunately, there is no legal framework or practices that would provide charges for these services. Measures on carbon dioxide reduction and absorption by forests do not get sufficient funding by the Belarusian government. Neither are they financially supported by foreign investors. At the same time several countries that have low carbon sequestration capacity of forests have access to free carbon markets of forestry ecosystem services and get investments.

Current hardly-predictable and rather negative dynamics of weather and climate impacts on the forest ecosystem puts tremendous stress (large-scale forest drying-out) on the forest sector of Belarus. This can affect sustainable development goals, i.e., seriously change the carbon budget of forests and direct ***the "net flow" of carbon in forests towards the atmosphere***. This change has been in place in the global forest ecosystem due to the "global deforestation" problem.

Highly-efficient carbon sequestration activity of the forest sector of Belarus (over the past six decades the forests of Belarus have deposited 7.7 billion t of atmospheric carbon dioxide) deserves attention of ***international investors***. High return on investment in the carbon sequestration services has been demonstrated by the forest sector of Belarus.

Task 2 was jointly performed by the leading scientists and forestry professionals:

L.N. Rozhkov, D.Sc. (Agriculture), Professor, Belarusian State Technological University;

I.V. Voitau, D.Sc. (Engineering), Rector of Belarusian State Technological University;

V.F. Baginskiy, D.Sc. (Agriculture), Professor, F. Skaryna Gomel State University;

L.L. Navoichik, PhD (Agriculture), Associate Professor, Republican Centre for Professional Development of Managerial Staff and Forestry Professionals;

A.S. Klysh, PhD (Agriculture), Associate Professor, Belarusian State Technological University;

D.I. Filon, PhD (Agriculture), Associate Professor, Belarusian State Technological University;

M.V. Yushkevich, PhD (Agriculture), Associate Professor, Belarusian State Technological University;

D.V. Shiman, PhD (Agriculture), Associate Professor, Belarusian State Technological University;

T.A. Zharskaya, PhD (Engineering), Associate Professor, Belarusian State Technological University;

O.V. Lapitskaya, PhD (Economics), Associate Professor, Head of Department, Sukhoy Gomel Technical University;

V.L. Krasovskiy, leading engineer, forest inventory RUE "Belgosles"

2.3. Principles and Criteria of a "Green Economy" for Forestry

An important issue while introducing principles of a "green economy" into the national economy sectors is development of a system of criteria and performance indicators [14, p. 103]. A strategic task is to develop and implement the principles and criteria of the "green economy" in the forest sector of the country which will result in conservation of forest resources and improved efficiency of their use and processing as well as to reduce energy dependence on fossil fuels.

Implementation and development of the "green economy" has an evolutionary way that was paved by certain actions undertaken by the world community:

– *The Club of Rome Report. Limits to Growth, 1972* (it was decided that the imbalance between production and consumption must not affect the ecological bearing capacity of the planet);

– *UN Conference on the Human Environment, Stockholm, 1972* (global environmental concerns were discussed);

– *United Nations Conference on Environment and Development, Rio de Janeiro, 1992* (the concept of sustainable development was broadened. A comprehensive plan of actions for XXI century – Agenda 21 – was adopted by 173 governments);

– *United Nations Millennium Declaration, 2000* (a step was made towards a broader view on the relationship between the environment, economy and social development);

– *United Nations Conference on Environment and Development, Johannesburg, 2002* (the focus was made on slowing down of climate change by means of reduced greenhouse gases emissions, conservation and regeneration of forests, less frequent nature and anthropogenic catastrophic events, etc.);

– *UN World Summit Rio+20,* Rio de Janeiro, 2012 (marked the **transfer to the "green economy" model**);

– *Rovaniemi Action Plan for the Forest Sector in a Green Economy*, 2013;

– the *Paris Agreement on Climate Change*, 2015;

– *United Nations Environment Programme* (*UNEP*) (main principles of the "green economy" were approved).

Most world countries including the Republic of Belarus supported the internationally adopted documents and conventions and committed to them with allowances made for specific features of the national economies.

In 2008 the United Nations Organization has started the "Green Economy" Initiative (GEI) that is based on global-scale studies and national-level support and aimed at encouraging the governments to make green investment in order to assist sustainable development.

The UN Environment Program suggests a working definition of a "green economy" as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.

The UNEP definition of a "green economy" is very broad. In its more narrow expression, a "green economy" is understood as development, production and utilization of technology and equipment used to control

and mitigate emissions of greenhouse gases and other pollutants, to monitor and forecast climate change impacts. It also involves energy- and resource-saving technology and renewable energy sources. In other words, a "green economy" embraces the actions and their outcomes that improve the quality of life and the living environment.

Main principles of the "green economy" by UNEP are as follows:

– justice and fairness within a generation and between generations;

– consistency with the sustainable development principles (sustainable development envisages catering for the needs of current generation without threatening the needs of future generations);

– preventive approach towards social impacts and environmental impacts;

– evaluation of natural and social capital, e.g., internationalization of external expenditures, green accounting, costs throughout the whole working life and improvement of management;

– sustainable and efficient use of resources, consumption and production;

– need for achieving the existing macroeconomic goals by creating "green" jobs, poverty eradication, increasing of competitiveness and growth of key economic sectors.

The key goal of the study phase has become development of the National Action Plan for Introduction of Principles of the "Green Economy" into the Forestry of the Republic of Belarus until 2030. In order to achieve this goal provisions of adopted international and national agreements, action plans, conceptions and other "green economy" related documents were widely used. The Action Plan was developed with due account of the existing best practices of the advanced countries which made progress in the "green economy" in the forest sector as well as with account of the similar national practices.

Methodology for the development of *principles and criteria of the "green economy" for the forest sector* of the Republic of Belarus was based upon commonly used national and international approaches towards developing National programs and plans, advanced methods of practical implementation of research outcomes that are built on:

– basic sustainable development principles;

– provisions of the Paris Agreement;

– principles of sustainable nature management;

– principles of sustainable forest management;

– "green" economy principles, etc.

It should be noted that the success in the "green economy" development differs essentially across countries. Therefore the following criteria (Figure 2.6) have been applied to select the countries for analyses of the best practices in introduction of the green economy into the forest sector.

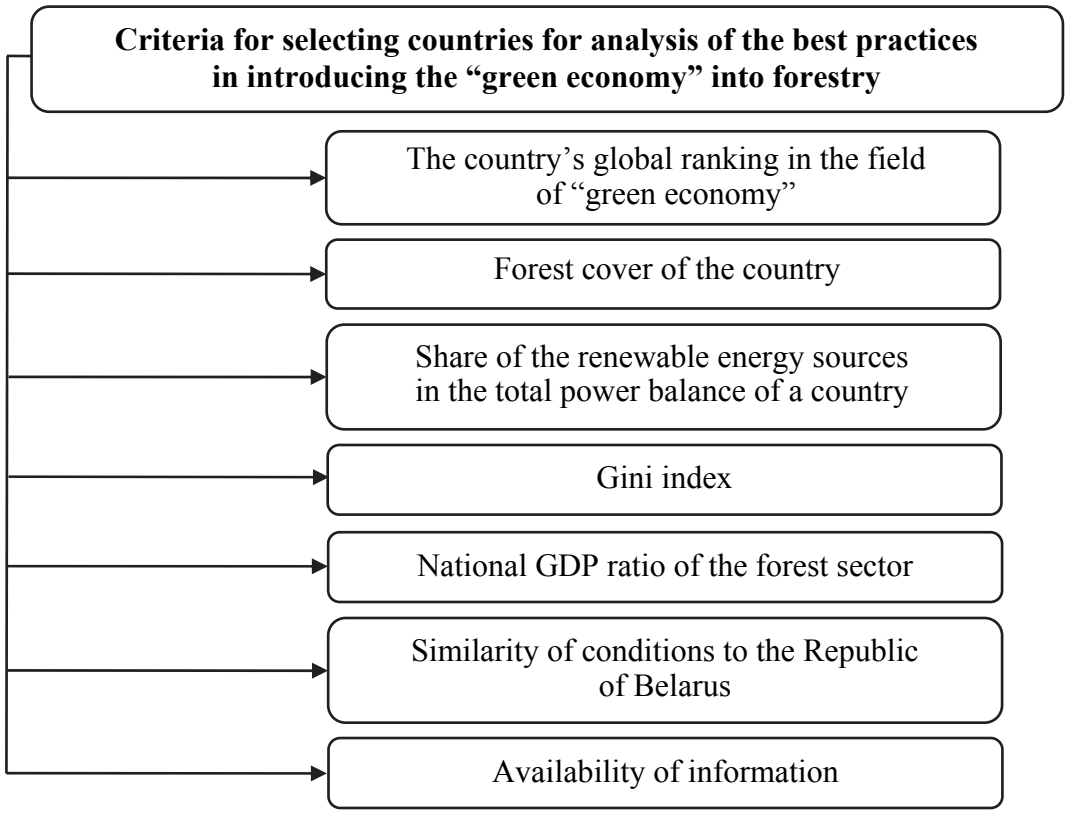

Figure 2.6. Criteria for selecting countries with best practices in introducing the "green economy" into forestry. (A.V. Lednitski)

Global rankings in the field of "green economy".

Global Green Economy Index GGEI – (published biannually by Dual Citizen International Agency). The index uses quantitative and qualitative indicators to measure how well each country performs on four key dimensions of the "green economy" [15]. The indicator of forests can be considered separately. This indicator measures the total area of tree loss divided by the forest cover since 2000 till present with the use of satellite data. To achieve a higher rank, a country shall focus on such actions as forest protection against fires, pests, catastrophic events, improved forest regeneration measures, etc.

Environmental Performance Index EPI. The Environmental Performance Index is a quantitative assessment and comparative analysis

of environmental performance indicators of the countries worldwide [16]. The index measures environmental progress and policymaking of a country on 20 performance indicators across 9 categories covering environmental health and ecosystem vitality. The index ranks the countries on their progress in several categories that are grouped as follows: *ecosystem vitality* (climate and energy, biodiversity, fisheries, forests, water resources); *environmental health* (health impact, air quality, water and sanitation). In the EPI report of 2016 the Republic of Belarus is ranked 35 among 109 countries. [15]. According to the EPI report, forests cover approximately 30.6% of the total land area on the globe, the global tree quantity is estimated to be about three trillion. Annually the global tree cover loss is approximately 15 billion trees. In the last 15 years the global tree cover loss rate has achieved 15% as compared to the period of 2001–2004 [16].

Eco-Innovation Index EII – (can be found on the European commission website) aims at capturing the different aspects of eco-innovation by applying 16 indicators grouped into five dimensions [17]:

1) *eco-innovation inputs*;
2) *eco-innovation activities*;
3) *eco-innovation outputs*;
4) *resource efficiency*;
5) *socio-economic outcomes*.

Forest cover. By this indicator a country is globally ranked either as forested or non-forested (forest cover less than 20–30%).

Share of renewable energy in total energy *(*power and heat). The share of renewable energy is one of the focal principles of the "green economy". For instance, this indicator makes 20% of the "Efficiency" performance indicator in GGEI. Several countries have already reached the 20202 EU renewable target of 20% [18], some countries have hit the 2050 EU target (55%) and are approaching the maximum target of 75%, among them are Sweden, Norway and Iceland [19].

Gini Index. Comparison of the Gini indexes makes it possible to assess social welfare in a country. Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution.

Forest sector's contribution to GDP. This index depicts the development of the forest sector in a country and how heavily the national GDP relies on the forest sector [20]. It illustrates the level of machine,

equipment and technological infrastructure of the forest sector's enterprises that are involved in high-added value production.

Similarity of the conditions to those of the Republic of Belarus. This quality parameter analyzes the feasibility of adopting the best practices in the field of "green economy" in the Republic of Belarus.

The ranks of more than 30 countries were summarized across the main criteria thus making it possible to select top 5 countries to analyze the best practices in the field of promoting the "green economy" in the forest sector. The 5 countries included Finland, Latvia, Germany, Canada and Poland. The review of best practices of implementation of "green economy" principles in forestry of the selected countries has made the following **conclusions and recommendations** possible:

1) the forest sectors of the selected countries can provide a good foundation for the development of "green economy" and sustainable growth;

2) forest management in the countries reviewed is based on the sustainability criteria that define not only sustainable forest use but give a broader definition of environmental, social and economic sustainability;

3) the forest policy of all the countries as well as the forest management policy, climate and energy policies, green economy policy rely on the adopted international conventions and plans;

4) legal framework of the countries is intensively developing with due regard to international conventions, "green economy" principles of the Rovaniemi Action Plan;

5) some specific features can be pointed out based on the practices of Poland and Latvia. These countries have a transition economy and their political and economic situation is similar to the past situation of East European countries. Moreover, they are neighbouring countries of Belarus and their practices can be adopted as follows:

a) creation of prerequisites for ecosystem service charges;

b) introduction of FSC certification standards;

c) addressing gender issues in the forest sector;

d) use of research outcomes, introduction of innovative methods and technologies of forest cultivation;

e) attraction of investments from the EU structural funds to the developments facilitating the transition towards a "green economy";

f) adoption of green public procurement practices.

One of the fundamental documents for implementation of the "green economy" principles is the **Rovaniemi Action Plan** for the forest sector in a green economy (hereinafter referred to as the Action Plan) that was adopted on December 13, 2013, in Finland under the aegis of United Nations Economic Commission for Europe (UN ECE) and FAO European Forestry Commission (EFC).

The Action Plan aims at linking forests and the "green economy" through replacing energy-intensive and non-sustainable products and processes by their forest-based alternatives. It also intends to further support forest ecosystem services and forest-based well-being in Europe, North America, Caucasus and Central Asia [21].

The Action Plan provides an overall vision, strategies and some application areas. Each application area contains objectives and specific activities, and identifies potential actors, who might contribute to achieving the stated objectives.

The Action Plan consists of 5 pillars with their respective goals:

1. Sustainable production and consumption of forest products.

Goal: Patterns of production, consumption and trade of forest products are truly sustainable.

2. A low carbon forest sector.

Goal: The forest sector makes the best possible contribution to mitigation (sequestration, storage and substitution) of, and adaptation to, climate change.

3. Decent green jobs in the forest sector.

Goal: The workforce is able to implement sustainable forest management, and the forest sector contributes to achieving the social goals of the green economy by providing decent jobs.

4. Long-term provision of Forest Ecosystem Services.

Goal: Forest functions are identified and valued and payments for ecosystem services (PES) are established, encouraging sustainable production and consumption patterns.

5. Policy development and monitoring of the forest sector in relation to a green economy.

Goal: Policies and institutions relevant to the forest sector promote sustainable forest management; policy making is evidence-based, policy instruments are effective, efficient and equitable and monitoring is adequate in order to mainstream the green economy in forest sector policies [22].

Figure 2.7 provides graphic illustration of the Action Plan.

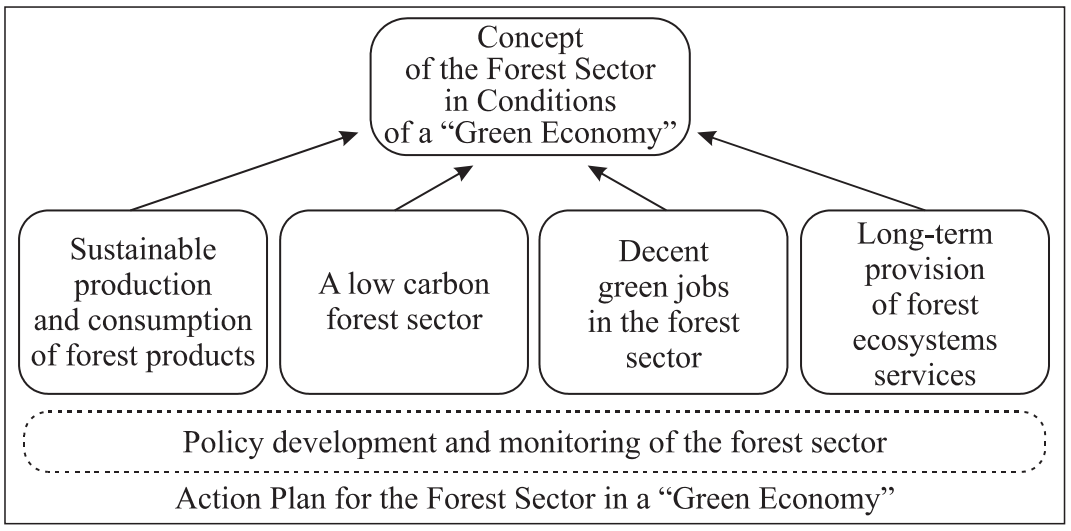

Figure 2.7. Graphic illustration of the Rovaniemi Action Plan [22, p.8]

Each pillar of the Action plan has its specific objective and 129 activities (Figure 2.8).

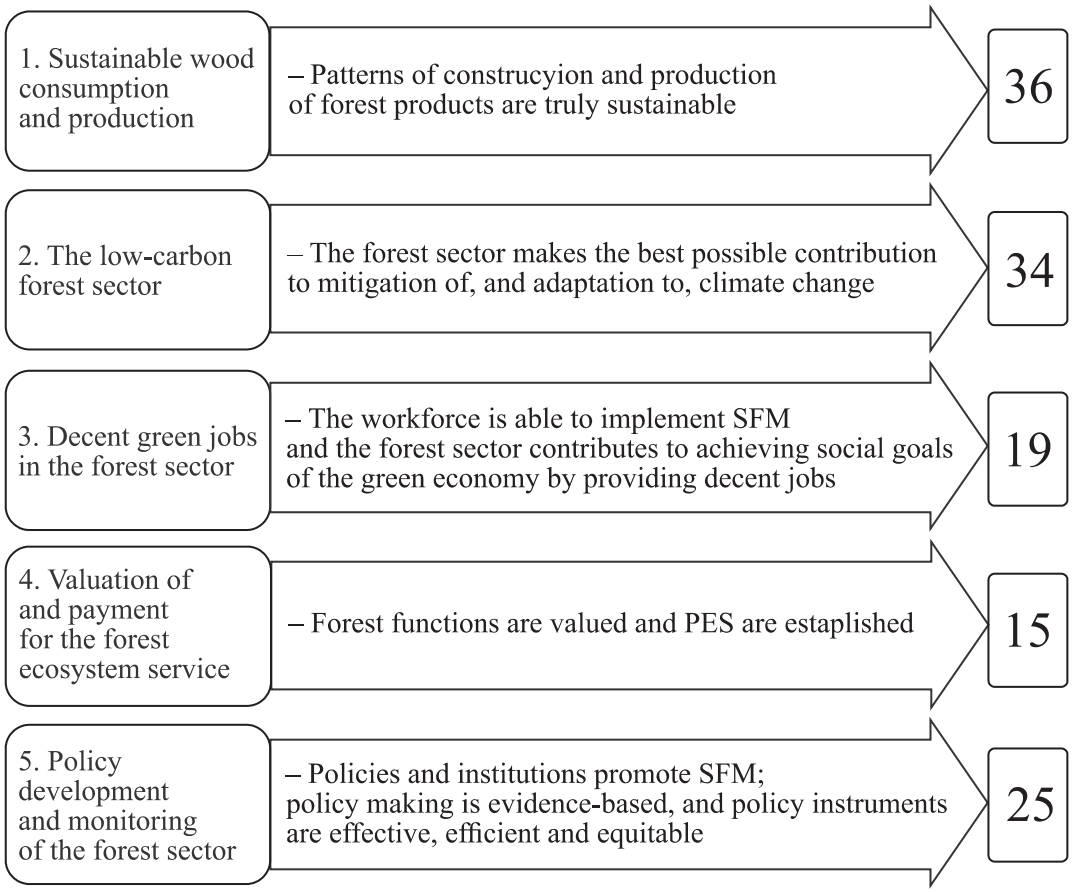

Figure 2.8. Pillars of the Rovaniemi Action Plan [23]

Principles of the forest sector in the emerging "green economy".

The Action Plan suggests that the forest sector adheres to the following principles by 2020:

– uses all its resources, especially those arising from the forest, wisely and economically, minimizing waste, recovering, reusing and recycling as much as possible;

– consumes only products from forests where it can be demonstrated that they are managed sustainably;

– contributes to mitigation of climate change by sequestering carbon in forests and forest products, and by substituting non-renewable products and fuels with renewable wood-based products and fuels;

– cares for and builds up its workforce, developing the necessary skills and significantly improving the occupational safety and health of workers and giving due consideration to gender equality;

– makes sure that the situation of forestry education is reviewed and improved;

– takes all externalities fully into account in policy making, introducing payment for forest ecosystem services whenever appropriate;

– bases its governance on evidence-based decision making and the transparent monitoring of progress towards sustainable forest management;

– provides products and services of high user/consumer value;

– seeks the active participation of civil society and the private sector.

The Rovaniemi Action Plan was developed for the UNECE region that embraces 56 countries, including the Republic of Belarus. The Action Plan is not a binding plan. The actions will be implemented, on a voluntary basis, by governments of member States, organizations and other stakeholders. The Action Plan provides a basis for plans and activities and the actors are free to adapt and amend it according to their conditions and needs.

Many of the actions specified by the Action Plan are being implemented or are planned ahead by the forest sector of the Republic of Belarus.

Based on the review of the Rovaniemi Action Plan the following key actions can be suggested for the forest sector of the Republic of Belarus:

– promote sustainable forest products in all sectors of economy;

– promote innovation intended to improve efficiency in the use of materials in the manufacturing and processing of forest products, and the competitiveness of the sector;

– create conditions and approaches which foster innovation (policies, framework conditions and changed attitudes);

– carry out studies on the current status of services related to forest products, and other marketable forest sector services, and their impact in terms of employment and value added;

– conduct study of the social and economic factors that in the future may affect the services of the forest sector (R&D, globalization, etc.);

– contribute to the development of green building;

– take into consideration the Good practice guidance on sustainable mobilization of wood in Europe (2009);

– invest in the forest sector, including infrastructure for forest growing, harvesting and processing [22].

The National Action Plan for the Development of the Green Economy in the Republic of Belarus until 2020 envisages the following **priority areas of "green" economy development**:

– development of electric transport (infrastructure) and urban mobility, implementation of the "smart" city concept;

– construction of energy-efficient residential housing and improved energy efficiency of the residential properties;

– reduced GDP energy intensity, increased energy efficiency;

– enhanced uses of renewable energy sources;

– creation of the enabling environment for organic production;

– sustainable consumption and production;

– ecotourism development.

The review of concepts and principles of a "green economy" in foreign countries and the Republic of Belarus has made it possible to justify and define **main "green economy" principles for the forest sector of the Republic of Belarus**:

1. Resource-efficient and sustainable use of forest resources;

2. Conservation, protection, development and adaptation of forests to climate change and promotion of their greenhouse gases absorption capacity;

3. Strong social policy and high standard of living due to forestry development and forest use;

4. Enhanced international prestige of the Republic of Belarus as a "green country";

5. Development of forest ecosystem services.

The suggested principles of "green economy" for the forest sector of the Republic of Belarus, the European best practices,

international documents and conventions, the existing legal framework and national forest management practices served as a basis for the development of criteria and related actions that have been incorporated in the draft National Action Plan for the Implementation of the Principles of the "Green Economy" in the Forestry of the Republic of Belarus until 2030.

The task was jointly performed by the following experts:

A.V. Lednitski – task manager, Associate Professor, PhD (Economics), Head of the Department of Enterprise Economy and Management, BSTU.

P.A. Protas – Associate Professor, PhD (Engineering), Associate Professor of the Department of Logging Machinery, Forest Roads and Timber Production Technology, BSTU.

O.V. Bakhur – Associate Professor, PhD (Biology), Associate Professor of the Department of Tourism, Nature Management and Game Management, BSTU.

O.A. Varapaeva – research fellow of the Department of Management, Business Technology and Sustainable Development, BSTU.

2.4. Brief Summary of the Concept of the "Climate-Oriented" Forestry Development

The conceptual line of the development of the Long-term Forestry Development Strategy of the Republic of Belarus with Low Greenhouse Gas Emissions for the period up to 2050 is defined by the methodology for the formation of an ecological and economic forestry system. The methodology is focused on forest stock increment and sustainable production of forest fund ecosystems, intensifying and efficiency of absorption and sequestration processes and the regulation of greenhouse gas emissions based on reasonable forest management.

The priority actions under the current Strategy include sustainable forest management focused on low greenhouse gas emissions during transition to a new forestry economy and employment of new toolkit.

Greenhouse gas emissions in forestry include annual removal of biomass from forest ecosystems resulting from all types of cuts, logging and utilization and its transformation into carbon dioxide, as well as other greenhouse effects caused by the life cycle of forest products.

The low-carbon development strategy includes long-term, medium-term and short-term objectives each having its specific activities.

The long-term low-carbon development strategy (Point 1 in Figure 2.9. "The Long-term Forestry Development Strategy of the Republic of Belarus with low greenhouse gas emissions until 2050") describes the expected path for sustainable development, the principal provisions of forest policy and forest management, new adequate realities and consequences of interaction between society and nature taking into account climate change. It helps to develop effective policy decisions and the nationally appropriate actions to prevent climate change [42], to establish priorities contributing into effective forest management and ensuring the increment of public goods, sustainable production of ecosystem services.

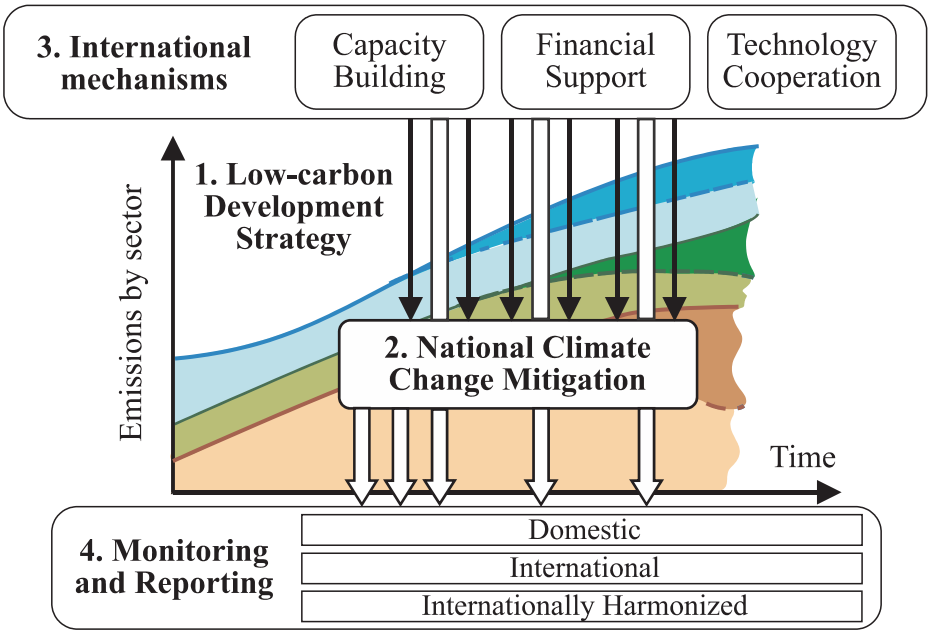

Figure 2.9. The relationship between the Long-term Forestry Development Strategy of the Republic of Belarus with low greenhouse gas emissions until 2050 and national actions for climate change mitigation*
The source: Based on the How-to Guide: Low-emission Development Strategies and Nationally Appropriate Mitigation Actions: Eastern Europe and CIS, UNDP, 2010

Nationally appropriate actions aimed at preventing climate change (Point 2 in Figure 2.9) constitute a set of specific activities and policy

* Hereinafter referred to as the "Climate-Oriented Strategy for Development of Forestry of the Republic of Belarus"

decisions stimulating the transfer of forestry to a low-carbon development path.

The mechanisms of international support (Point 3 in Figure 2.9) can be used for nationally appropriate climate change mitigation.

Monitoring and reporting (Point 4 in Figure 2.9) are necessary for obtaining international support for nationally appropriate actions in climate change mitigation, which requires detailed quantitative and qualitative data.

The need in more thorough link between the processes of absorption and emission in forest ecosystems (the amount of the biomass increment and its share in forest management) determines the development of a special forest policy.

The special forest policy is a forest policy which provides a rationale for objectives of the system of measures for addressing climate challenges and increasing the role of forests as a global environmental resource.

Climate-oriented development of forestry involves addressing two main issues:

1. Adaptation of forest sector to climate change.
2. Enhancing contribution of the forest sector to climate stabilization.

These problems are interrelated, the second one can be considered within the framework of the first one (as a process and an element of adaptation).

From the point of view of system analysis and strategic decision-making, approaching forestry as climate stabilization factor is politically significant.

A climate-oriented forest policy is a policy which expresses international ecological value of a country's forests and provides their sustainable reproduction under conditions of climate change instability and increase of ecological risks.

The climate-oriented forest policy is not just strengthening of the country's position as concerns the forestry's response to climate change. It also means emerging of a new historical role of the country in addressing global environmental challenges. Moving forward in this direction cannot be successful without international consensus and involvement, including financial and economic aspects.

Implementing the climate-oriented forest policy requires development of adequate forest management. The climate-oriented forestry is a natural and economic (ecological and economic) system based on priorities and values of steady environmental management, the "green"

economy principles, reduction of GHG emissions by forests, working practices for increase of forest productivity, reduction of environmental risks, steady reproduction of natural capital and profitable forest management [43].

Taking into account that climate-oriented forestry development is environment-focused in its essence it is reasonable to use the terms "climate-oriented" and "environmentally friendly" as synonyms (when considering environmental issues).

The following experts took part in implementation of task “Preparing Long-term Forestry Development Strategy of the Republic of Belarus with low greenhouse gas emissions until 2050” within Activity 3.1.4.:

A.V. Neverov – Professor of the Department of Management, Business Technology and Sustainable Development of BSTU, DSc (Economics);

D.G. Malashevich – senior lecturer of the Department of Management, Business Technology and Sustainable Development of BSTU;

A.V. Ravino – Associate Professor of the Department of Management, Business Technology and Sustainable Development of BSTU, PhD (Economics);

N.T. Yushkevich – Associate Professor of the Department of Tourism, Nature Management and Game Management of BSTU, PhD (Economics).

3. STRATEGY FOR ADAPTATION OF THE BELARUSIAN FOREST SECTOR TO CLIMATE CHANGE UNTIL 2050

3.1. General Provisions

Climate is defined as an average mode of weather for a certain period of time. Climate change is characterized by a deviation from the average magnitudes of temperature, precipitation, wind direction and strength, occurrence of extreme events (droughts, frosts, strong winds, rains, snowfalls, etc.). The climate has always had a significant impact on the human activities. Such sectors of economy as agriculture, forestry and water management are particularly affected by climate. Scientists-climatologists indicate that without taking active measures to reduce the concentration of greenhouse gases in the Earth's atmosphere, the average daily temperature on the planet may increase by 2–7°C by 2100.

Since 1989, the longest warming period has been observed in Belarus for the whole time of instrumental temperature record during the last 130 years. Over the period from 1989 to 2015 the average annual air temperature in Belarus has exceeded the climatic norm adopted by the World Meteorological Organization (WMO) by 1.1°C. The specific feature of the changing air temperature in Belarus is its sharp rise, by almost 4°C, in January and February, and by 2°C in March and April. The abnormal temperature rise in March and April causes early melting of snow cover. Besides, the temperature rises above 0°C two or three weeks earlier than usual.

The warming has affected the boundaries of the agro-climatic zones, distinguished by active vegetation period, i.e. based on the sum of air temperatures above 10°C. The northern agro-climatic zone has divided into two parts, and a new, warmer agro-climatic zone has been formed in the south of the Belarusian Polesie. According to the opinion of numerous scientists, global warming in the coming decades will continue, so we can expect further shift northward of the boundaries of agro-climatic regions with higher temperatures. For this reason, there is

a need of periodic clarification of the boundaries of agro-climatic zones, which should be conducted once every ten years.

Due to a significant increase in the average annual temperature, the forestry in the southern and eastern parts of Belarus already faces a problem of insufficient soil moisture, which leads to weakening of forest stands and consequently to large-scale forest drying-out and exposure to diseases and infestation.

Data analysis shows that droughts covering several regions on the territory of Belarus are becoming more frequent. The frequency of droughts increases from north-west to south-east. For example, in the Gomel region, the frequency of droughts with a coverage area of at least 30% of the region is approximately 1 time in 2 years, in Brest – once in 2–3 years.

At present, up to 30 dangerous hydrometeorological phenomena are registered on the territory of the Republic annually. Most of them are of a local nature. However, such phenomena as frosts, hurricane winds causing windbreaks and windfalls in the forests, heavy rains, forest fire hazard sometimes occupy a large area of the country.

According to the forecasts, increase of the average annual air temperature by 1°C and prolongation of the vegetation period by almost two weeks (and by the end of the century up to one month) is expected by 2039 in Belarus. In addition, a significant increase in precipitation in winter and spring, rise of temperature during vegetation period, and increase in aridity due to lack of moisture are expected.

Many European countries recognize the problem of climate change as a significant threat to the future of our planet and have already begun to take proactive measures to reduce the climate change impacts. Undoubtedly, forests play a decisive role in regulating the temperature regime on the planet, since they are main carbon dioxide sinks.

3.2. Current State of the Forest Fund and Effects of Climate Change on its Structure

As of January 1, 2018, the total area of the forest fund of the Republic of Belarus equaled to 9,582.8 thousand ha, the forested area of the country is 39.8% (Figure 3.1).

All forests without exception are state-owned, there are no private forests. The state administrative bodies and agencies having the right of

forest management comprise the following entities: the Ministry of Forestry of the Republic of Belarus (88.0% of the area), the Office of the President of the Republic of Belarus (7.9%), the Ministry for Emergency Situations (2.3%), the Ministry of Defence (0.9%), The National Academy of Sciences of Belarus (0.4%), the Ministry of Education (0.3%) and local executive and administrative bodies (0.2%). Forests are managed by 118 legal entities, 98 of them are under the Ministry of Forestry.

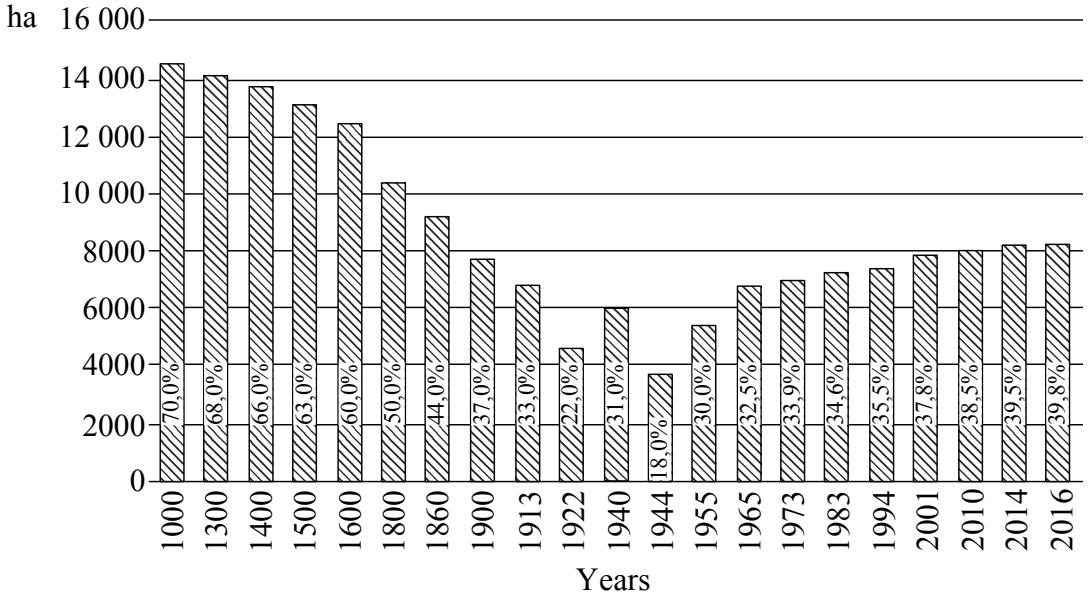

Figure 3.1. Dynamics of the forest cover of the Republic of Belarus

Lands covered with forests occupy the area of 8,260.9 thousand ha, including exploitable forests of 6,563.2 thousand ha or 79.4%. The total stock of stands is 1,796.0 million m^3, of which 1,459.8 million m^3 or 81.3% can be exploited.

The predominant forests are coniferous (59.4%), more than half of which are *Pínus sylvestris* plantations (50.0%). Forests with prevalence of *Pícea ábies* make up 9.4%, *Betula pendula* and *Bétula pubéscens* – 23.1%, *Álnus glutinósa* – 10,5%, *Quércus róbur* – 3,5%, *Pópulus trémula* 2,2% (Figure 3.2).

Maple, Ash, Linden, Willow, Hornbeam, and Elm tree species are often found in mixed stands, but the share of plantations with predominance of these native species does not exceed 1% in total. Local forest tree species that are endangered are *Ábies álba* and *Quércus pétraea*. The area of *Fráxinus excélsior* has recently been significantly reduced due to its massive drying out.

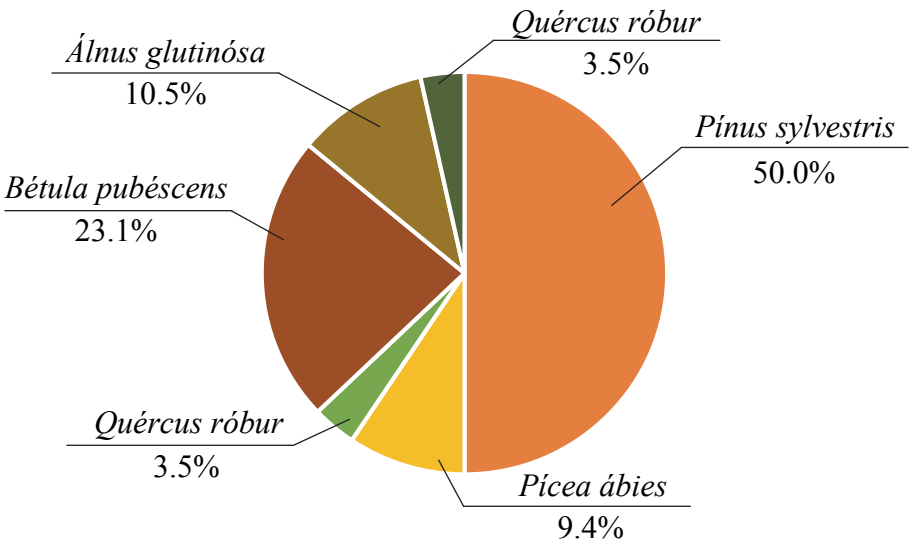

Figure 3.2. Distribution of the forest fund of Belarus by species

Introduced plants are mainly presented by *Lárix decídua* plantations, individually by *Pínus sibírica*, *Pínus stróbus* and *Populus balsamifera* with a total area of about 1.2 thousand ha. The invasive tree species include *Robínia pseudoacácia* and *Ácer negúndo*.

The age structure of the country's forests is uneven and requires optimization: young stands – 17.8%, middle-aged – 43.0%, ripening – 24.5%, mature and over-mature – 14.7%. The average age of forest stands is 56 years, the average density is 0.71, the average stock of stands is 217 m^3/ha. As for the main species, Scots pine, its average stock is 241 m^3/ha. Mixed stands with the share of 2–3 species of 58.1% predominate. The stands with one species in the composition equal to 26.9%. The main series of forest types are mossy, bracken, fern, sorrel, myrtillus, polytric.

The specially protected natural areas contain 1,169.4 thousand ha of stocked forest lands (14.2%). Among them are forest lands of the Berezinsky Biosphere reserve (76.4 thousand ha), National Parks (269.0 thousand ha), nature sanctuaries (814.3 thousand ha), and the areas belonging to the natural landmark (10.8 thousand ha).

The total cost of forest resources as of 01.01.2018 amounted to 22.2 billion Belarusian rubles, including the cost of stem wood – 10.6 billion Belarusian rubles (48%). The cost of 1 ha of stocked forest land amounted to 2.7 thousand rubles, 1 ha of the total area of the forest fund – to 2.3 thousand rubles.

Climate change can have a significant impact on the productivity of forest ecosystems, species composition and biodiversity, the risks of forest

fires, the risks of mass breeding of pests and spread of forest diseases, the risks of windfalls and windbreaks in forests and, in general, on the economic conditions and social aspects of the forestry management.

The climate effects forest plantations through the change in the level of groundwater, forest fires, windfalls and windbreaks, the reproduction of insect pests. This leads to the change in the species composition and structure of the forests. The temperature rise leads to the earlier start of plants' vegetation and therefore to enhances risk of trees damage by frosts. The main growth of wood occurs in spring and the first half of summer and decreases in the second half of the vegetation period due to the lack of moisture in the soil.

The lack of rains and hot weather in July – August affect the fire situation in the forests and the sustainability of stands. In the future, in case no measures are taken, there will be a threat of rapid growth of environmental and economic damage as a result of droughts which may affect the sustainable development of the Republic.

As a result of climate change, the species that are at the edge of their distribution range in Belarus (*Pícea ábies*, *Cárpinus bétulus*, *Álnus incána*) will be shifted to the north. This will be caused by the fact that at the edge of the range these species live in harsh conditions as concerns temperature regime and dry climate.

Climate change influences the shift of plant blooming periods, as well as enhances risk of damage of vegetative organs by the late spring frosts. Prolongation of the vegetation period will lead to increment of plantations, thus causing necessity to adjust the age of commercial cuts, thinnings and intermediate felling. The lack of moisture in summer period can have a negative impact on the productivity of stands in the southern regions of the country and cause reduction in the resistance of stands to pests and diseases.

The possibility of extreme and unfavorable hydrometeorological conditions may also increase the risk of windfalls and windbreaks, promote the spread of diseases and pests in forests, and affect the emergence of new, more aggressive forms.

Thus, the most significant impacts of climate change on forestry are:

– change in the composition of stands in connection with the change in stability and the shift in the ranges of the main forest-forming species;

– active overgrowing of marshes by woody and shrubby vegetation due to a general decrease in the level of groundwater and an increase in the intensity of evaporation from the surface of swamps and their water catchment areas;

– the general acceleration of the circulation of substances in forest ecosystems, in particular, the rate of decomposition of tree waste and forest litter;

– enhanced probability of large-scale breeding of forest pests due to a general decrease in the resistance of tree species in combination with improved conditions for reproduction of foliage-eating insects and stem pests;

– increased risk of penetration of invasive pathogens and forest pests;

– impoverishment of flora and fauna of forests in combination with the introduction of forest-steppe and steppe complexes into forest ecosystems;

– enhanced probability of emergence of late-spring frosts due to earlier start of vegetation period and their harmful effect on wood plants;

– a decline in increment of stands under conditions of frequent droughts during the growing season and the lack of moisture at the beginning of vegetation;

– deterioration of wintering conditions for forest plants due to absent or short-term snow cover and thinning of the snow layer;

– change in timing of ripening of foetuses and seeds of woody plants, as well as forest berries caused by earlier start of vegetation period;

– deterioration of accessibility to exploitable marshy forests in winter period due to poor soil freezing;

– an increase in the duration of fire danger period and the number of forest fires that will lead to the release of a significant amount of carbon dioxide, which will exacerbate climate change.

3.3. State Policy in the Field of Forestry Adaptation to Climate Change

The Republic of Belarus is a party to the United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Paris Agreement to the Framework Convention and implements international commitments as follows: implementing the national climate policy, preparing national communications on climate change issues, maintaining the state cadastre of anthropogenic emissions by sources and absorption of greenhouse gases by sinks, preforming climate observations and scientific research. In accordance with the obligations the Republic of

Belarus should implement domestic policies and implement measures aimed at reducing the anthropogenic impact on the climate.

On November 16, 2015, Decree of the President of the Republic of Belarus No.461 «On the Draft International Agreement" was signed. The Decree approves the position of the Republic of Belarus during negotiations on the draft international agreement to the UN Framework Convention on Climate Change, as well as the obligation of the country to reduce greenhouse gas emissions by 2030 by not less than 28% from the 1990's level, excluding emissions and sinks within the sector "Land Use, Land-Use Change and Forestry".

Implementation of the state policy in the field of forest management, including adaptation of forestry to climate change, is provided by the Ministry of Forestry. The legislative framework on utilization, security, protection and reproduction of forests is based on the Constitution of the Republic of Belarus and consists of the Forest Code of the Republic of Belarus, acts of the President of the Republic of Belarus and other documents. The State Program "Belarusian Forest" for 2016–2020 has been developed in order to fulfill the tasks set by the President and the Government of Belarus with regard to the forest sector, with a focus on raising efficiency in the subsectors of forest industry, wood processing, furniture production, pulp and paper and wood chemical manufacturing. The program also aims at introduction of modern technologies, usage of best practices of the Republic of Finland and other countries with highly developed forestry and timber industry sector. Furthermore, The Strategic Plan for the Development of the Forestry Sector for the period from 2015 to 2030 has been developed. The main provisions of these documents include activities on promoting the conservation of biological and genetic diversity of forests, strengthening their role in preserving the biosphere, increasing forest stands' resilience to climate change. Both documents include high priority activities on updating national forest policy and legislative framework, improving the attractiveness of forest sector for the country's economy.

The following regulatory and legal documents are also aimed at climate change mitigation:

The State Program "Environmental Protection and Sustainable Use of Natural Resources" for 2016–2020, approved by Resolution № 205 of the Council of Ministers of the Republic of Belarus dated March 17, 2016. The Program gives great importance to conservation of forest ecosystems, in particular, old-growth stands that play an essential role in formation of microclimate and improvement of ecological situation.

The Program proposes a range of climate change mitigation activities. One of them is increasing the forest coverage by creating hardwood forest plantations. In order to create forests resistant to climate change it is also proposed to select and introduce into current reforestation and afforestation system the southern origin climatypes mostly adapted to the country's forest-growing conditions;

The Strategy for the Conservation and Sustainable Use of Biological Diversity for 2011–2020, approved by Resolution № 1707 of the Council of Ministers of the Republic of Belarus dated November 19, 2010, "On Some Issues in the Field of Conservation and Sustainable Use of Biological Diversity" (National Register of Legal Acts of the Republic of Belarus, 2010, № 287, 5/32887). The document examines the main challenges in the field of conservation and sustainable use of biological diversity in the Republic of Belarus, identifies the tasks to be solved, including conservation of biological and genetic diversity of forests and forest landscapes with account of the increasing anthropogenic and climate change impacts, sustainable use of forest resources, strengthening the role of forests in conservation of the biosphere;

The National Strategy for the Development of the Network of Specially Protected Natural Areas until January 1, 2030, approved by Resolution № 649 of the Council of Ministers of the Republic of Belarus dated July 2, 2014, "On the Development of a System of Specially Protected Natural Areas" (National Legal Internet Portal of the Republic of Belarus, 11.07 .2014, 5/39101);

The National Action Plan for the Prevention of Land Degradation (including soils) for 2016–2020, approved by Resolution № 361 of the Council of Ministers of the Republic of Belarus dated April 29, 2015 (National Legal Internet Portal of the Republic of Belarus, May 6, 2015, 5/40478).

3.4. Objectives and Areas of Focus in Implementation of the Strategy, Priorities in Adaptation of Forestry to Climate Change

The objectives of the Strategy are: resisting the negative impact of climate change on forestry, increase of the forest cover of the territory, preservation of the gene pool of forest stands, increase of their sustainability and productivity.

To achieve the set goals, it is necessary to carry out a set of measures in the following areas:

– improvement of the legal and regulatory framework, taking into account the adaptation of the Belarusian forestry to climate change;

– improvement of the monitoring system of the state of forests with monitoring of processes caused by the effects of climate change;

– improvement of technologies and methods of reforestation and afforestation taking into account climate change;

– preservation of the genetic potential of the forests of the Republic;

– increase at the genetic level of the adaptive capacity of forest stands to climate change;

– improvement of methods and technologies for safety and protection of forests taking into account climate change;

– rise in the forest cover across the country;

– development of a mechanism for assessing changes in the volume of emission quotas and their implementation through the Emissions Trading System;

– improvement of professional training system, advanced training and internships, including foreign internships of specialists of the forestry sector on the most acute issues of forest management in the context of climate change;

– organization of ongoing scientific support of the industry with an emphasis on the most acute and new problems in forest growing, caused by climate change in Belarus.

The responsible executors, the volume and timing of activities on the adaptation of forestry in the Republic of Belarus to climate change are given in the Annex to the draft Strategy.

These directions are the basis for the development of the National Plan for the adaptation of forestry in Belarus to climate change for the period 2018–2030.

3.5. Expected Results and the Strategy Implementation Arrangements

As a result of implementation of this Strategy by 2050 the following results will be achieved:

– stability and productivity of forest stands will increase;

– forest cover of the territory will grow up to 42.0%;

– the share of mixed plantations will increase up to 77%;

– the share of hardwood stands will increase up to 6.5%;

– the share of natural renewal will be at least 50% of the total reforestation with a reduction of the areas of natural renewal without measures of assistance;

– no less than 71 hectares of geographic plantations of local and promising introduced species, will be created. That will allow to monitor the state of forest plantations of different geographical origin under conditions of climate change;

– the final felling area will increase with preservation of the undergrowth up to 7%;

– the area of non-clear commercial cuttings will increase up to 35% of the total volume of final felling;

– the share of the formation of mixed plantations during improvement felling will be 92% of the total area of stands that are in need of improvement felling;

– the share of combined regeneration of forests will increase up to 20% in the total scope of reforestation work, which will make it possible to make greater use of the forest potential for natural regeneration;

– the share of creation of forest cultures with the use of planting and sowing material of hardwood species with the expansion of their list will increase up to 12.5%;

– the share of mixed forest cultures will be 95% of the total area of artificial regeneration and afforestation;

– the volume of reforestation, including combined reforestation, using container seedlings should be at least 30% of the total volume of reforestation and afforestation, which will increase the sustainability and productivity of future stands;

– the area of genetic reserves, allocated on the basis of the most valuable natural stands, will reach 1.5% of the total area of the forest fund;

– in the clonal archives, all genotypes of allocated plus and high quality trees will be represented;

– on the entire territory of the forest fund, the work on identification and use of local populations that are resistant to the negative effects of climate change will be carried out in forest seed production;

– the share of seeds of forest plants of selected category, harvested at the seed stands created by ‘population’ seed management will increase up to 20%;

– the creation of forest cultures will be ensured by selective seed and planting material at the level of 50%;

– the coverage of the early forest fire detection system based on remote sensing method will reach 95% of the forest fund area;

– at least 3 300 km of forest roads, increasing the availability of forest fund sites in extreme weather conditions and forest fires will be built;

– the area of forest pathological surveys of the forest fund, using remote sensing methods, will cover at least 3 million hectares per year;

– the area of expedition forest pathological surveys will be carried out on an area of at least 100.000 ha per year;

– forest protection measures using environmentally safe biological methods will be carried out on an area of at least 120 000 ha per year.

The present Strategy should be executed through implementation of the measures on adaptation of Belarusian forestry to climate change until 2050, at the expense of funds provided for state programs on forestry and nature management, international technical assistance and of other sources not prohibited by law (Tables 3.1, 3.2).

Table 3.1

Targets of the Strategy for Adaptation of Forestry in Belarus to Climate Change until 2050

Target value	Units of measurement	Annualised rate			
		2020	2030	2040	2050
1. Forest cover percentage	Percent	40.1	41	41.5	42.0
2. Share of mixed plantations	Percent	72.8	74.0	75.4	77.0
3. Share of stands with a predominance of hardwood species	Percent	4.5	5.5	6.0	6.5
4. The proportion of natural regeneration in total reforestation	Percent	45	47	49	50

Table 3.2

Activities on Adaptation of Forestry in Belarus to Climate Change

Activity, index, unit of measurement	Responsible	Annualised rate			
		2018–2020	2021–2030	2031–2040	2041–2050
1. Improvement of the legal and regulatory framework, taking into account the adaptation of Belarus' forestry to climate change	Ministry of Natural Resources and Environmental Protection, Ministry of Forestry, Ministry of Education, National Academy of Sciences	Constantly			

Table 3.2 (continued)

Activity, index, unit of measurement	Responsible	Annualised rate			
		2018–2020	2021–2030	2031–2040	2041–2050
2. Improvement of the monitoring system of the state of forests including control of processes caused by climate change – creation of provenance trial plantations in an area, ha	Ministry of Forestry, Ministry of Education, National Academy of Sciences	–	35	53	71
3. Improvement of technologies and methods of forest felling taking into account climate change – the area of final felling with preservation of the undergrowth, % of the total final felling area	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	2	4	5	7
– share of partial felling, % of the volume of cut timber during final felling	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	20	33	34	35
– formation of mixed stands during improvement felling, % of the stands area that are in need of improvement felling	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	80	85	90	92

Table 3.2 (continued)

Activity, index, unit of measurement	Responsible	Annualised rate			
		2018–2020	2021–2030	2031–2040	2041–2050
4. Updating approaches, technologies and methods of reforestation and afforestation taking into account climate change – share of the combined forest renewal, % of the total reforestation area, not less than	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	5	15	20	20
– share of the creation of forest plantations using seed and planting material of hardwood species, % of the area of artificial reforestation and afforestation	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	11.5	11.7	12.0	12.5
– share of mixed forest plantations, % of the area of artificial reforestation and afforestation	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	70	87	90	95
– number of tree species used for reforestation and afforestation, units, not less than	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	8	10	11	12

Table 3.2 (continued)

Activity, index, unit of measurement	Responsible	Annualised rate			
		2018–2020	2021–2030	2031–2040	2041–2050
– share of reforestation and afforestation using container seedlings, % of the area of artificial reforestation and afforestation	Ministry of Forestry	30	30	30	30
4. Preservation of the genetic potential of forests – area of genetic reserves,% of forest fund area, not less than	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus	0.05	0.3	0.8	1.5
– establishment of clone archive of high quality trees, % of the selected trees	Ministry of Forestry, Ministry of Education, National Academy of Sciences	20	50	80	100
– establishment of clone archive of elite trees, % of the selected trees	Ministry of Forestry, Ministry of Education, National Academy of Sciences	100	100	100	100
5. An increase of adaptive capacity of forest stands to climate change at the genetic level – identification and use of local populations in forest seed production that are resistant to the negative effects of climate change (with simultaneous creation on their basis of forest seed orchards of population selection and test plantations) number of legal entities that are engaged in farming not less than: – Pine – Spruce	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	 28 14	 76 73	 100 99	 118 118

Table 3.2 (continued)

Activity, index, unit of measurement	Responsible	Annualised rate			
		2018–2020	2021–2030	2031–2040	2041–2050
– the share of seeds of forest plants of the selected category, harvested at the stands created by 'population' seed management,%	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	–	2	8	20
– the percentage of creation of forest plantations by selection seed and planting material,% of the area of artificial reforestation and afforestation	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	50	50	50	50
6. Improvement of security and protection methods and technologies of forests taking into account climate change in Belarus – coverage of the early forest fire detection system based on remote methods, % of the forest fund area	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	90	95	95	95
– construction volume of forest roads, km	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	300	1 000	1 000	1 000

Table 3.2 (continued)

Activity, index, unit of measurement	Responsible	Annualised rate			
		2018–2020	2021–2030	2031–2040	2041–2050
– the area of forest pathological surveys of the forest fund, including using remote methods, thousand ha, per year	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	1 500	2 000	2 500	3 000
– area of expedition of forest pathological surveys, thousand ha, per year	Enterprise “Belgosles”	70	100	100	100
– carrying out measures to protect forests using environmentally safe biological methods, thousand hectares, per year	Ministry of Forestry, Ministry of Education, Ministry of Defence, Ministry of Emergency Situations, National Academy of Sciences, Office of the President of the Republic of Belarus, regional administration	60	80	100	120

4. NATIONAL ACTION PLAN FOR ADAPTATION OF FORESTRY TO CLIMATE CHANGE UNTIL 2030

The draft National Action Plan for Adaptation of Forestry to Climate Change to 2030 (Table 4.1) is prepared on the basis of the developed Strategy for Adaptation of Forestry to Climate Change for the Period to 2050 and includes a list of activities proposed for improving adaptation of forestry to climate change, the amount of work that should be carried out, the distribution of activities proposed in phases, and a list of responsible executors from the forest fund holders for each activity.

The distribution of the activities of the National plan for forest fund holders was made on the basis of the peculiarities of the composition of the forest fund under their management and the specific features of forest management.

Table 4.1

National Action Plan for Adaptation of Forestry to Climate Change to 2030

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
Improvement of the monitoring system of the state of forests and holding control of processes caused by the impact of climate change				
1. Creation of geographical cultures of Scots pine, ha, not less than – in the first agro-climatic zone	Vitebsk State Forestry Production Association	–	1	–
– in the second agro-climatic zone	Vitebsk State Forestry Production Association	–	1	–
	Minsk State Forestry Production Association	–	1	–
	Mogilev State Forestry Production Association	–	1	–

Table 4.1 (continued)

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
– in the third agro-climatic zone	Grodno State Forestry Production Association	–	1	–
	Minsk State Forestry Production Association	–	1	–
	Mogilev State Forestry Production Association	–	1	–
– in the fourth agro-climatic zone	Brest State Forestry Production Association	–	1	–
	Gomel State Forestry Production Association	–	1	–
2. Creation of geographical cultures of European spruce, ha, not less than – in the first agro-climatic zone	Vitebsk State Forestry Production Association	–	1	–
– in the second agro-climatic zone	Vitebsk State Forestry Production Association	–	1	–
	Minsk State Forestry Production Association	–	1	–
	Mogilev State Forestry Production Association	–	1	–
– in the third agro-climatic zone	Grodno State Forestry Production Association	–	1	–
	Minsk State Forestry Production Association	–	1	–
	Mogilev State Forestry Production Association	–	1	–
3. Creation of geographical cultures of Silver fir, ha, not less than – in the second agro-climatic zone	Grodno State Forestry Production Association	–	–	1
	Minsk State Forestry Production Association	–	–	1
	Minsk State Forestry Production Association	–	–	1
– in the fourth agro-climatic zone	Brest State Forestry Production Association	–	–	1

Table 4.1 (continued)

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
4. Creation of geographical plantations of Common oak, ha, not less than				
– in the second agro-climatic zone	Vitebsk State Forestry Production Association	–	1	–
	Grodno State Forestry Production Association	–	1	–
	Minsk State Forestry Production Association	–	1	–
	Mogilev State Forestry Production Association	–	1	–
– in the third agro-climatic zone	Grodno State Forestry Production Association	–	1	–
	Minsk State Forestry Production Association	–	1	–
	Mogilev State Forestry Production Association	–	1	–
– in the fourth agro-climatic zone	Brest State Forestry Production Association	–	1	–
	Gomel State Forestry Production Association	–	1	–
5. Creation of geographical plantations of European beech, ha, not less than				
– in the second agro-climatic zone	Grodno State Forestry Production Association	–	–	1
	Minsk State Forestry Production Association	–	–	1
– in the third agro-climatic zone	Grodno State Forestry Production Association	–	–	1
	Minsk State Forestry Production Association	–	–	1
– in the fourth agro-climatic zone	Brest State Forestry Production Association	–	–	1

Table 4.1 (continued)

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
Improvement of technologies and methods of forest felling taking into account climate change				
1. Area of final felling with preservation of undergrowth,% of total final felling area	Brest State Forestry Production Association	1.3	2.1	3.6
	Vitebsk State Forestry Production Association	2.6	3.5	4.5
	Gomel State Forestry Production Association	1.8	2.8	3.8
	Grodno State Forestry Production Association	1.6	2.6	3.8
	Minsk State Forestry Production Association	1.5	2.7	3.8
	Mogilev State Forestry Production Association	2.9	3.8	4.3
	Ministry of Defence	2.0	3.0	4.0
	Ministry of Emergency Situations	2.0	3.0	4.0
	Ministry of Education	2.0	3.0	4.0
	Office of the President of the Republic of Belarus	2.0	3.0	4.0
	National Academy of Sciences	2.0	3.0	4.0
	oblast administration	2.0	3.0	4.0
2. The share of non-clear cuts, % of the volume of timber harvest during final felling	Brest State Forestry Production Association	23	26	33
	Vitebsk State Forestry Production Association	22	25	33
	Gomel State Forestry Production Association	20	24	33
	Grodno State Forestry Production Association	20	23	33
	Minsk State Forestry Production Association	20	23	33
	Mogilev State Forestry Production Association	26	28	33
	Ministry of Defence	22	25	33
	Ministry of Emergency Situations	22	25	33
	Ministry of Education	22	25	33
	Office of the President of the Republic of Belarus	22	25	33
	National Academy of Sciences	22	25	33
	regional administration	22	25	33

Table 4.1 (continued)

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
3. Formation of mixed stands during thinnings, % of the area of stands which need cutting	Ministry of Forestry	81	83	86
	Ministry of Defence	66	67	71
	Ministry of Emergency Situations	71	73	76
	Ministry of Education	76	77	78
	The Office of the President of the Republic of Belarus	76	78	80
	National Academy of Sciences	81	82	86
	regional administration	61	65	70
Improvement of approaches, technologies and methods of reforestation and afforestation taking into account climate change				
1. Share of combined forest regeneration, % of total reforestation area, not less than	Ministry of Forestry	5	10	15
	Ministry of Defence	5	10	15
	Ministry of Emergency Situations	5	10	15
	Ministry of Education	5	10	15
	The Office of the President of the Republic of Belarus	5	10	15
	National Academy of Sciences	5	10	15
	regional administration	2	3	5
2. Share of the creation of forest cultures by planting and seed material of hardwood species, % of the area of artificial reforestation and afforestation	Ministry of Forestry	11.7	11.8	11.9
	Ministry of Defence of the Republic of Belarus	5.4	6.0	6.5
	Ministry of Emergency Situations of the Republic of Belarus	7.3	8.0	9.5
	Ministry of Education of the Republic of Belarus	8.5	10.0	11.5
	Office of the President of the Republic of Belarus	7.1	7.5	8.0
	National Academy of Sciences of Belarus	9.7	10.2	10.7
	Local governmental and executive bodies	7.5	7.5	7.5
3. The share of mixed forest cultures, % of the area of artificial reforestation and afforestation	Ministry of Defence, Ministry of Emergency Situations, Ministry of Education , Office of the President of the Republic of Belarus, National Academy of Sciences, Regional administration	70	80	87

Table 4.1 (continued)

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
4. The number of tree species used for reforestation and afforestation, pcs.	Brest State Forestry Production Association	8	9	9
	Vitebsk State Forestry Production Association	8	9	10
	Gomel State Forestry Production Association	8	9	9
	Grodno State Forestry Production Association	8	9	10
	Minsk State Forestry Production Association	8	9	10
	Mogilev State Forestry Production Association	8	9	10
	Ministry of Defence	8	8	8
	Ministry of Emergency Situations of the Republic of Belarus	8	8	8
	Ministry of Education of the Republic of Belarus	8	9	10
	Office of the President of the Republic of Belarus	8	9	10
	National Academy of Sciences	8	9	10
	local administrative and executive bodies	8	8	8
5. Share of reforestation and afforestation using container seedling, %	Ministry of Forestry	30	30	30
Preservation of the genetic potential of forests				
1. The area of genetic reserves is not less than, % of the area of the forest fund	Ministry of Forestry	0.05	0.15	0.3
	Office of the President of the Republic of Belarus	0.05	0.05	0.3
2. The volume of creation of clonal archives of high quality trees, not less than, % of the selected trees	Brest State Forestry Production Association	20	35	50
	Vitebsk State Forestry Production Association	20	35	50
	Gomel State Forestry Production Association	20	35	50
	Grodno State Forestry Production Association	20	35	50
	Minsk State Forestry Production Association	20	35	50
	Mogilev State Forestry Production Association	20	35	50
	Ministry of Education	20	35	50
	National Academy of Sciences	20	35	50

Table 4.1 (continued)

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
3. The volume of creation of clonal archives of elite trees, not less than, % of the selected trees	Brest State Forestry Production Association	100	100	100
	Vitebsk State Forestry Production Association	100	100	100
	Gomel State Forestry Production Association	100	100	100
	Grodno State Forestry Production Association	100	100	100
	Minsk State Forestry Production Association	100	100	100
	Mogilev State Forestry Production Association	100	100	100
	Ministry of Education	100	100	100
	National Academy of Sciences	100	100	100
Increase in the genetic level of the adaptive capacity of forest stands to climate change				
1. Identification and use of local populations of Scots pine in forest seed production that are resistant to the negative effects of climate change, the number of legal entities engaged in forestry	Brest State Forestry Production Association	6	5	3
	Vitebsk State Forestry Production Association	–	1	–
	Gomel State Forestry Production Association	7	7	7
	Grodno State Forestry Production Association	2	3	2
	Minsk State Forestry Production Association	5	4	4
	Mogilev State Forestry Production Association	4	4	1
	Ministry of Defence of the Republic of Belarus	1	1	–
	Ministry of Emergency Situations of the Republic of Belarus	–	1	–
	Ministry of Education of the Republic of Belarus	–	1	–
	Office of the President of the Republic of Belarus	1	1	1
	National Academy of Sciences of Belarus	2	–	–
	local administrative and executive bodies	–	1	1

Table 4.1 (continued)

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
2. Identification and use of local populations of European spruce, resistant to negative climate change in forest seed production, the number of legal entities conducting forestry	Brest State Forestry Production Association	4	5	5
	Vitebsk State Forestry Production Association	1	1	
	Gomel State Forestry Production Association	2	10	9
	Grodno State Forestry Production Association	–	4	3
	Minsk State Forestry Production Association	2	3	2
	Mogilev State Forestry Production Association	3	5	4
	Ministry of Defence of the Republic of Belarus	–	1	–
	Ministry of Emergency Situations of the Republic of Belarus	–	1	–
	Ministry of Education of the Republic of Belarus	–	1	–
	Office of the President of the Republic of Belarus	1	1	1
	National Academy of Sciences	–	1	–
	local administrative and executive bodies	1	1	1
3. The percentage of forest plantations with selective planting and sowing material, % of the area of artificial reforestation and afforestation	Ministry of Forestry Ministry of Defence Ministry of Emergency Situations Ministry of Education The Office of the President of the Republic of Belarus, National Academy of Sciences regional administration	50	50	50
4. Share of seeds of forest plants of selected category, harvested at stands created by the ‘population’ seed management,%	Ministry of Forestry Ministry of Education National Academy of Sciences	–	1	2

Table 4.1 (continued)

Activities	Responsible	Implementation in stages		
		2018–2020	2021–2025	2026–2030
Improvement of methods and technologies for preservation and protection of forests taking into account climate change in Belarus				
1. Coverage of early forest fire detection system based on remote sensing methods, % of forest fund area	Ministry of Forestry Ministry of Defence Ministry of Emergency Situations Ministry of Education The Office of the President of the Republic of Belarus, National Academy of Sciences	90	92	95
2. The stretch of constructed roads, km	Ministry of Forestry	300.0	500.0	500.0
3. Area of forest pathological surveys of the forest fund, including with the use of remote methods, thousand ha per year	Ministry of Forestry Ministry of Defence Ministry of Emergency Situations Ministry of Education The Office of the President of the Republic of Belarus, National Academy of Sciences	1 500	1 700	2 000
4. Area of expedition-based forest pathological surveys, thousand ha per year	Enterprise “Belgosles”	70	90	100
5. Implementation of measures to protect forests using environmentally safe biological methods, thousand ha per year	Enterprise “Bellesozaschita”, Ministry of Forestry, Ministry of Education, The Office of the President of the Republic of Belarus, National Academy of Sciences, Ministry of Defence, Ministry of Emergency Situations	60	70	80

5. NATIONAL ACTION PLAN ON INCREASING THE ABSORPTION OF GREENHOUSE GASES BY SINKS (FORESTS, SWAMPS) UNTIL 2030

5.1. General Provisions

The National Action Plan on Increasing the Absorption of Greenhouse Gases by Sinks (Forests, Swamps) until 2030 is an implementation mechanism of the United Nations Strategic Plan for Forests for the period from 2017 to 2030 (UNSPF) [33] with regard to Global Forest Goal 1.2 "The world's forest carbon stocks are maintained or enhanced" and a contribution of the forest sector of the Republic of Belarus to Sustainable Development Goals (SDG) as a member country of Sustainable Forest Management (SFM).

This National Plan is a contribution of the forest sector into the implementation of Presidential Decree of the Republic of Belarus No.345 dated 20.09.2016 by which Belarus committed to the Paris Agreement with pledge to reduce greenhouse gases emissions. The National Plan specifies forestry actions within the State Program of Measures on Climate Change Mitigation for 2013–2020 approved by the Resolution of the Council of Ministers of the Republic of Belarus No.510 dated 21.06.2013 [34].

Climate change of the recent decades has been caused by increased concentration of greenhouse gases in the atmosphere. Main greenhouse gases that have destabilizing effect on the atmosphere are carbon dioxide, methane, nitrogen oxide and chlorofluorocarbons. The total amount of greenhouse gases is dominated by carbon dioxide (76%).

Absorption of substances by forest vegetation occurs during nutrition process. The nutrition can be divided into carbon or aerial, plant nutrition (photosynthesis), water nutrition (hydrogen and oxygen), nitrogenous and mineral.

Plants take up nitrogen through their roots in the form of mineralized ammonia nitrogen. Specific weight of absorption of nitrogen oxide by

plants is inconsiderable as compared to nitrogen fixation of atmospheric molecular nitrogen. Thereby forests have no significant impact on mitigation of the greenhouse effect.

Main biological sink of atmospheric methane is its oxidation in soil. Methane absorption by forest fund is relatively small, i.e., about 0.5 million t in CO_2 equivalent.

Natural absorption of chlorofluorocarbons by Belarusian forests is lower than 4 t per year.

The role of forest and other vegetation communities of the forest fund as greenhouse gases sinks is exercised through carbon dioxide absorption during primary synthesis of organic substances (photosynthesis). In view of this, the measures for forests and swamps contained in this National Action Plan include measures on increasing the level of carbon dioxide absorption by all types of forested lands of the Republic of Belarus.

Forestry of the Republic of Belarus has a good potential to considerably affect the extent and direction of carbon flows in the global carbon cycle. Growth of phytomass in the forest ecosystem of Belarus for the past six decades has ensured considerable increase in carbon stock from the atmosphere to the forest and its sequestration in wood and soils of forested lands. The planned long-term measures and actions in the forest sector provide objective prerequisites for sustainable dynamics of carbon dioxide absorption by the forest fund and commitments of the Republic of Belarus to reduce greenhouse gases emissions.

5.2. Belarusian Forests as Carbon Sinks

Dynamic development of the forest ecosystem in Belarus has a sustained tendency for increasing forest productivity and wood stock (Table 5.1).

Over the period from 1945 to 2017 the total forest fund area has increased 1.55 times (+3406.8 thousand ha), the productivity (average wood stock) increase 3.1 times (+125 cubic metres per 1 ha), total wood stock – 5.5 times (+1,451.3 million cubic metres). This was made possible through effective forestry operations of forest regeneration and forest growing, measures on increasing productivity and improving forest care, rational forest utilization, etc.

Table 5.1

Forest Fund Dynamics in the Republic of Belarus

Inventory years	Total forest fund area, thousand ha	Total wood stock, million cubic metres	Average wood stock per 1 ha, cubic metres	Total wood stock dynamics, million cubic metres
1945	6159.0	321.20	70	12.4
1956	7345.3	490.20	77	17.3
1961	8014.0	470.17	70	18.3
1973	8205.1	697.60	99	19.4
1983	8264.9	732.89	102	20.0
1994	8676.1	1093.23	148	20.7
2004	9341.0	1382.40	178	26.8
2014	9477.2	1692.70	207	31.9
2017	9565.8	1772.50	215	37.6

Increase of wood stock and phytomass of the forest ecosystem respectively leads to enhanced carbon net flow from the atmosphere to forest with its subsequent absorption. Since 1956 (first post-war forest inventory) the carbon content has increased in the forest fund. As of 01.01.2017 the carbon pool of the forest fund of the Republic of Belarus comprised 3,492.7 million tons (Figure 5.1). The increase of the forest fund area in 1.3 times resulted in the subsequent increase of carbon pool in 2.52 times. The carbon increment is almost twice as much as the forest fund increment. This resulted from a number of factors.

Firstly, we should mention a key permanent factor of measures to enhance forest productivity as the main strategic goal of the forest sector. This also improves the carbon sequestration capacity of forests. Conventional and new forestry operations are in place on the condition that they enhance forest productivity.

The list of the actions is quite long, they are too varied and form an integral part of all forestry activities. We will focus on certain results of such activities.

There was a monitoring of long-term (nearly 60 years) effect from the forestry measures on wood stock increment and annual carbon sequestration by the stands in Ivye experimental production forest district and Negoreloe experimental forestry district. During the monitoring a considerable increase of carbon sequestration capacity was registered. By methods of forest regeneration after final fellings the increase of

carbon sequestration was established as follows: forest plantations – +140 tC/year, natural reforestation with assistance measures – +0.99 tC/year. Increase resulting from forest care activities comprised: restoration with subsequent forest plantation – +1.39 tC/year, improvement fellings – +1.18 tC/year [35].

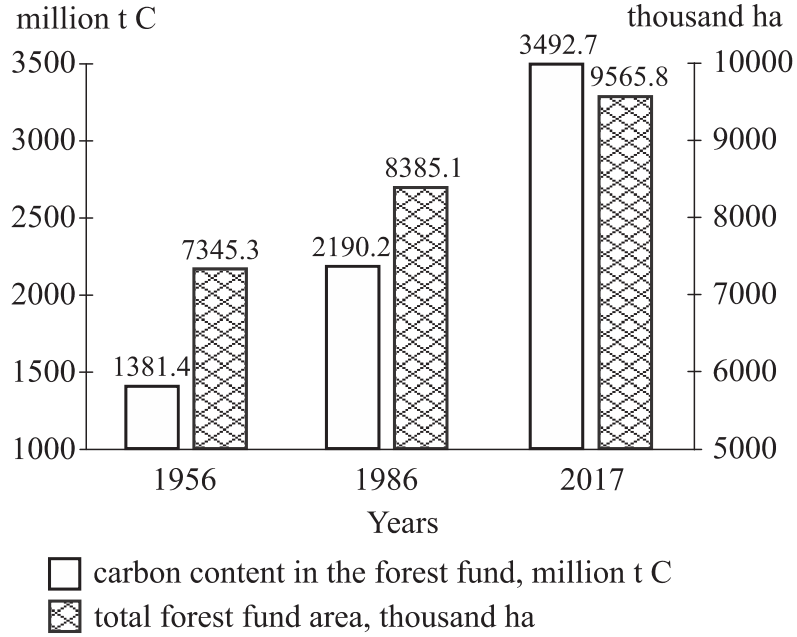

Figure 5.1. Dynamics of carbon content and the forest fund area in the Republic of Belarus (L.N.Rozhkov)

Secondly, a current factor of great impact on carbon sequestration is the present age structure of forest and wood harvest volumes. The current age structure of forests is not the optimal one but is very conducive to wood increment and associated carbon sequestration. The present index of age structure of national forests is equal to 0.30; the optimal age structure has an index set to zero. Today medium-aged stands occupy 44.3% of the forested areas and are by 14.3% higher than the optimal share. Medium-aged stands are characterized by maximum current wood increment that favors current increase of carbon pool in Belarusian forests.

Thirdly, the forest sector of Belarus experienced an extension of areas of forest group I accompanied by restricted wood harvest for the past three-four decades. At the same time, the share of commercial forests of group II was decreasing (1983 – 64%, 2015 – 45.1%). Thus, as the total forest area was increasing over the period from 1944 to

2015 (+4075.8 thousand ha), the area of commercial forests decreased by 441.0 thousand ha. The reduction of the commercial forest area of group II and the allowable cut limitations imposed by the "Rules of Forest Felling of the Republic of Belarus" brought about low intensity of forest utilization in Belarus as compared to other countries. Wood harvest volumes per unit of total volume comprised 9.7 and 13.0 m^3 per 1000 m^3 of total volumes in 2013 and 2016 respectively that is 1.4 times as little as in Poland, twice as little as in Austria and 3.8 times as little as in Finland [36].

The above mentioned factors have increased the values of annual total stock dynamics: 1983 – 20.0 million m^3, 2017 – 37.6 million m^3 (Table 5.1). Considerable changes in forest fund area are not predicted in the long-term perspective. The age structure of forest will remain non-optimal. The decreasing share of medium-aged stands will lead to significant reduction of wood volumes. The increasing share of mature forests will make it necessary to increase the allowable cuts regardless of the limitations prescribed by the new Forest Code (2015). Experts estimate that 57% of the available mature stands will be cut until 2050. 22% of the wood volume is exempt from final cuts for nature conservation purposes. Considerable wood volumes are hardly accessible. Mature stands in the zones of radioactive contamination with ^{137}Cs density over 15 Ku/km^2 are regarded as wood harvest reserves and are subject to cut restrictions. Under these conditions total average stock dynamics will decrease to 15–17 million m^3 or 2.5 times as little as of 01.01.2017 [10]. This dynamics will cause the reduction of carbon dioxide absorption by forest fund so that specific compensatory measures will be required to maintain the values achieved in 2017.

The component structure of carbon accumulated in the Belarusian forest fund (3,492.7 million t – Figure 5.1) is determined by regional soil and climate conditions and tree species structure. A vitally important feature of carbon flows is the predominance of storage form of carbon cycle (Figure 5.2) aimed at sequestration of soil carbon by forests [11].

Nearly three quarters of forest carbon pool of Belarus are organic soil carbon (73.37%). Nearly two thirds of the carbon sequestered by swampy forests (1.64 billion tC) and swamps (0.5 billion tC) have been withdrawn from the biological cycle for long-term conservation (Figure 5.3).

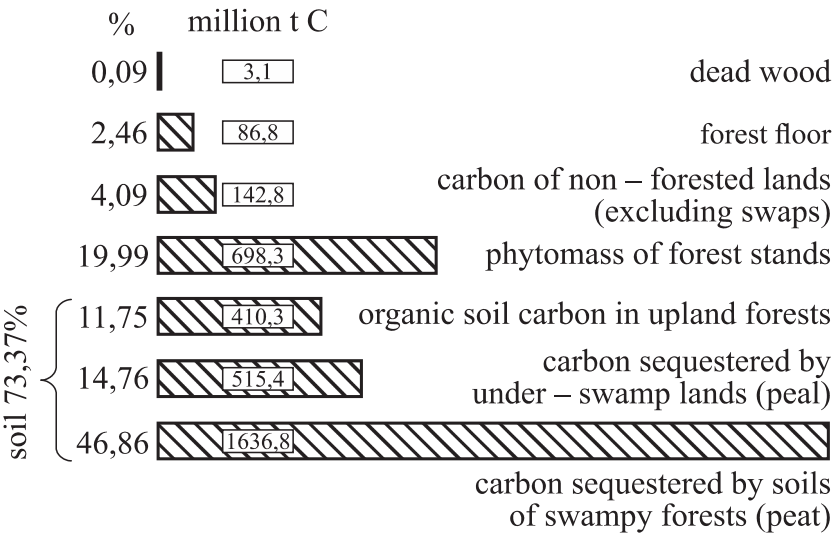

Figure 5.2 Component structure of carbon budget of the forest fund areas in Belarus (L.N. Rozhkov)

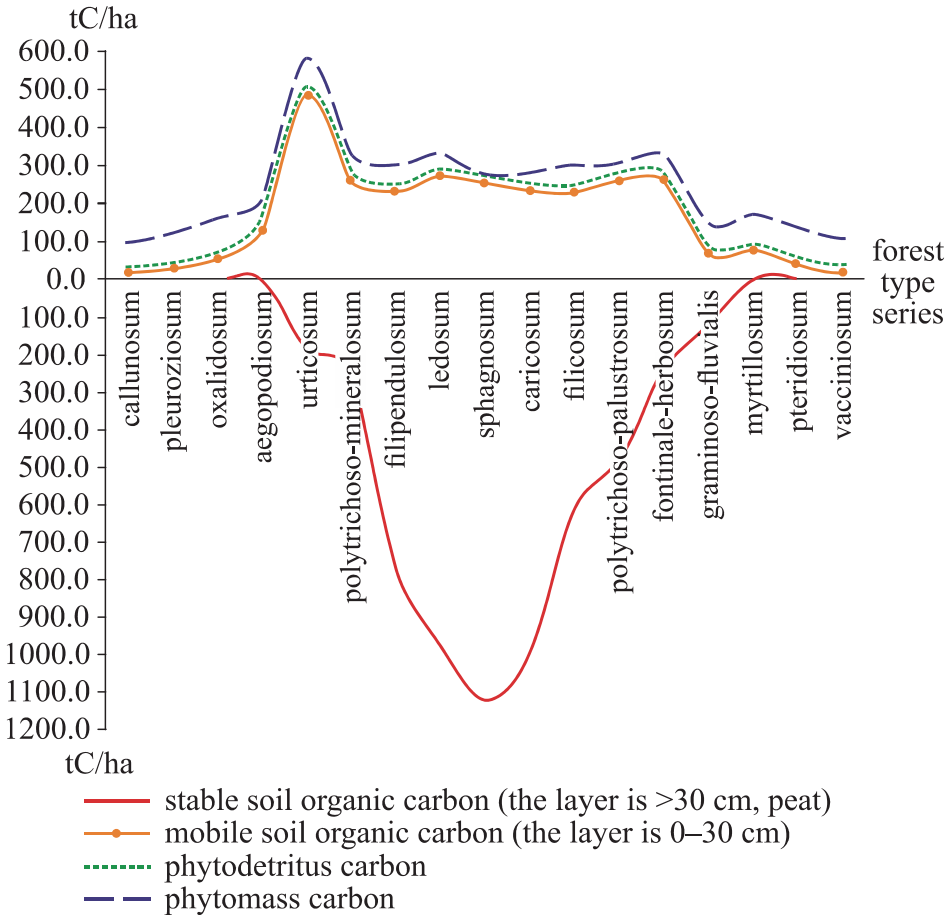

Figure 5.3. Carbon storage by forest stands in different forest growing conditions (L.N. Rozhkov)

Small biological cycle of the national forests involves 1340.5 million tC (38.38% of forest fund carbon). Phytomass carbon, deadwood carbon, forest floor carbon and carbon in the upper 10-cm soil layer ("conventionally mobile carbon") are involved in the most active biological cycle. The total carbon volume is estimated at 1,073.9 million t. The remaining carbon amount (in 10-30 cm soil layer) belongs to the "conventionally stable" biocycle [11].

Another specific feature of biocycle and net flows of carbon "stock-emission" in the forest ecosystem of Belarus is the excess of total photosynthesis of forest vegetation over plant respiration and phytodetritus decomposition ("soil respiration"). This fact can be confirmed by the dynamics of carbon stock sequestered by the forest fund within the permanent boundaries, i.e., without account of lands transferred to the forest fund. For the last six decades the carbon content within the conventionally permanent forest fund area has increased as follows: +567 million tC in phytomass and +780 million tC in soil. Thus, we can observe accelerated carbon synthesis by forest phytomass and decelerated rate of "soil respiration". Both processes assist in absorption of carbon dioxide from the atmosphere.

Over the period from 1956 to 2017 the forests of Belarus have captured about 2 111 million t of atmospheric carbon with subsequent sequestration in phytomass and soils of the forest fund (Figure 5.1). This amount can be compared to the "stock" (absorption) of nearly 7.740 million t CO_2. Over the same period the increment of CO_2 ("emission") in the earth atmosphere amounted to approximately 420 billion t, so the sustainability of carbon sequestration capacity of Belarusian forests deserves high appreciation.

It has been noted before that a key factor of the growing dynamics of carbon dioxide absorption is enhanced forest productivity due to proper forest management. Strongly positive effect has been achieved due to the following forestry measures: reduction of forest regeneration periods up to three years on non-forested lands, such as former felling sites, fire sites, etc.; creation of forest plantations by large-sized planting stock, root-balled planting stock, genetically improved planting stock; well-timed tending of plantations; forest pest and disease control in open plantations; transfer of open forest cultures to forest fund within 6–7 years from their creation.

The above mentioned measures can be supplemented by the following: extension of commercial forest areas for partial final cuts

with a focus on natural methods of forest regeneration of target (principal) tree species and reduction of cutting cycle by minimum 5–7 years; use of ecologically sound logging technology with conservation of young growth; assistance measures after final stages of gradual cuts to ensure normal density (1.0) of the remaining young growth; biological melioration (leguminous plants, other biomeliorating plants) of forest plantations as well as young growth of natural and man-made origin; selection of main tree species and target structure of forest stands based on soil-typological forest growth conditions; restoration of low-valuable and low-density young forests and medium-aged stands; strict compliance with the improvement cuts regulations [37]. It is possible to extend the forest cover of Belarus.

The forest sector of Belarus should be given credit for large-scale carbon sequestration by phytomass and forest fund soils (Figure 5.4), the same level of carbon dioxide absorption must be maintained and, if possible, increased in future as this is a key factor of CO_2 removal from the atmosphere. This becomes one of the major goals of the Belarusian forest sector due to the aggravating weather and climate change resulting from greenhouse gases emissions. Contribution of the forest sector to climate mitigation will be assessed by the increment of annual carbon dioxide absorption by the forest fund. Annual carbon dioxide absorption measured in tC/year is synonymous to average change in carbon sequestration by the forest fund measured in tC/ha/year (Figure 5.4).

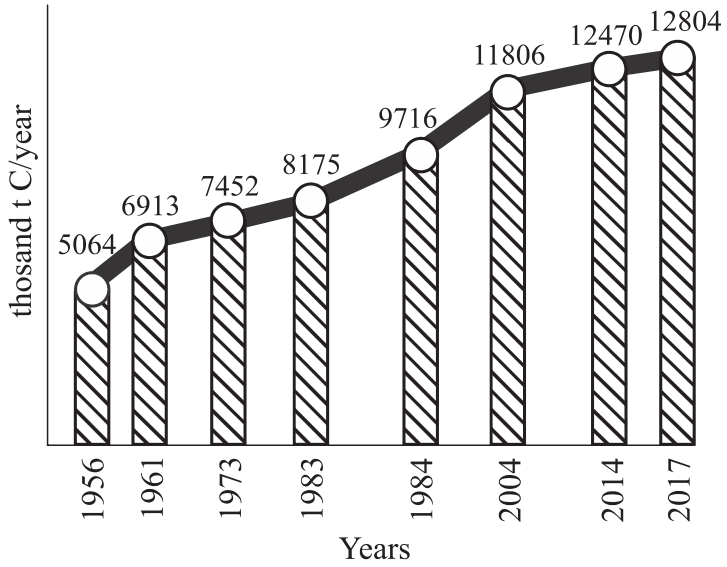

Figure 5.4. Total dynamics of carbon
sequestered by the forest fund of Belarus (L.N. Rozhkov)

Average periodical annual carbon dioxide absorption by the forest fund (1956-2017) is estimated at 10.64 tCO_2/ha/year. During certain periods the value of annual absorption varied from 3.8 to 14.4 tCO_2/year that can be attributed to the transfer of lands to the forest fund, wood harvest volumes, forest regeneration and forest growing.

In 2005 Belarus acceded to the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). The first National Communication on the UNFCCC commitment of Belarus introduced the amount of greenhouse gas emissions. In 2011 the Guidance for evaluation of total and annual carbon sequestration by forests of the Republic of Belarus was approved and made effective by order of the Ministry of Forestry of the Republic of Belarus No.81 dated 28.03.2011 [38]. From that time onward the record of carbon content in the forest fund has been kept in the Forest Cadastre and forest inventory projects.

Over the past 10–15 years the transfer of lands has been rather small-scale and the forest fund area has not changed considerably. For this reason the basic value of annual carbon dioxide absorption by forest fund should be set to 4.91 t CO_2/year. This value has been established as average periodical for 2000–2017 and remained unchanged even after the sweeping windblow in 2016. The emergency forest damage of 2016 proved the sustainability of the national forest sector in maintaining high level of annual carbon dioxide absorption at 46986 thousand t of atmospheric carbon dioxide.

5.3. Forecast of Absorption of Carbon Dioxide by the Forest Fund of the Republic of Belarus until 2030

Carbon balance of the forest fund is not time-stable due to the dynamics of wood stock and the level of forest utilization. Carbon budget can be altered by the following factors: reduced areas of forested lands, changing age structure of forests due to increasing areas of mature and ripening stands, increased wood harvest by final fellings, regeneration cuts, conversion and other cuts. These factors are also able to redirect the net flow of carbon into the atmosphere. Carbon flow monitoring and mechanism of their calculation are important tasks of the forest sector. Predominating “emission” in the carbon balance of the Belarusian forest ecosystem can adversely affect the national forest

sector under the conditions of globally rising pressure in the field of carbon dioxide emission into the atmosphere.

Sustainable and dynamic development of forestry in the Republic of Belarus creates good conditions for maintaining the earlier established dynamics of forest fund (Table 5.1) both in the short-term (until 2030) and long-term (until 2050) prospects. Whereas the total area of the forest fund will remain unchanged (9,565.8 thousand ha), the forested lands are predicted to increase until 2030 (+80.6 thousand ha) with the total wood increment of 47.4 million m^3. Steady wood harvest volumes can ensure stabilized carbon budget in the forests of Belarus (Table 5.2, Figure 5.5).

Table 5.2

Carbon Budget of the Forest Fund in the Republic of Belarus as of 01.01.2017

No.	Carbon budget indicators	Value
1	Total carbon of the forest fund, million tC	3,492.7
2	Phytomass carbon of the forest fund, million tC	698.3
3	Dead phytomass carbon of the forest fund, million tC	89.1
4	Organic soil carbon of the forest fund, million tC	2,705.3
5	Average carbon sequestration by the forest fund, tC/ha	365
6	Total change in carbon sequestration by the forest fund, thousand tC/year	12,804
7	Average change in carbon sequestration by the forest fund, tC/ha/year	1.61
8	Annual carbon dioxide absorption by the forest fund, tCO_2/year	46,986

The stock of atmospheric carbon mainly occurs in the forest stands under the Ministry of Forestry (Figure 5.5). They occupy 88% of the total forest fund area and are responsible for 90.63% of the annual level of carbon dioxide absorption by the Belarusian forests. Therefore, sustainability of carbon sequestration by national forests is dependent on the decision-making by the principal forest fund owner. It should be taken into account that the current age structure of forests is moving towards the mature ones, the allowable cut volumes are being increased and the demand for wood resources is growing on the domestic market. The listed factors can result in the decrease of carbon dioxide absorption by forests. Wood harvest volumes should be given special focus here.

The wood harvest in the Belarusian forests is predicted to enlarge. Improvement fellings have been excluded when calculating the carbon flows from intermediate cuttings. Trees to be cut for thinning are selected from the trees that are likely to naturally die. Such measures do not affect the level of carbon dioxide absorption. On the contrary,

timber transportation after final felling, regeneration, conversion and other cuts is regarded as the process of "instant wood oxidation" associated with the carbon dioxide emission.

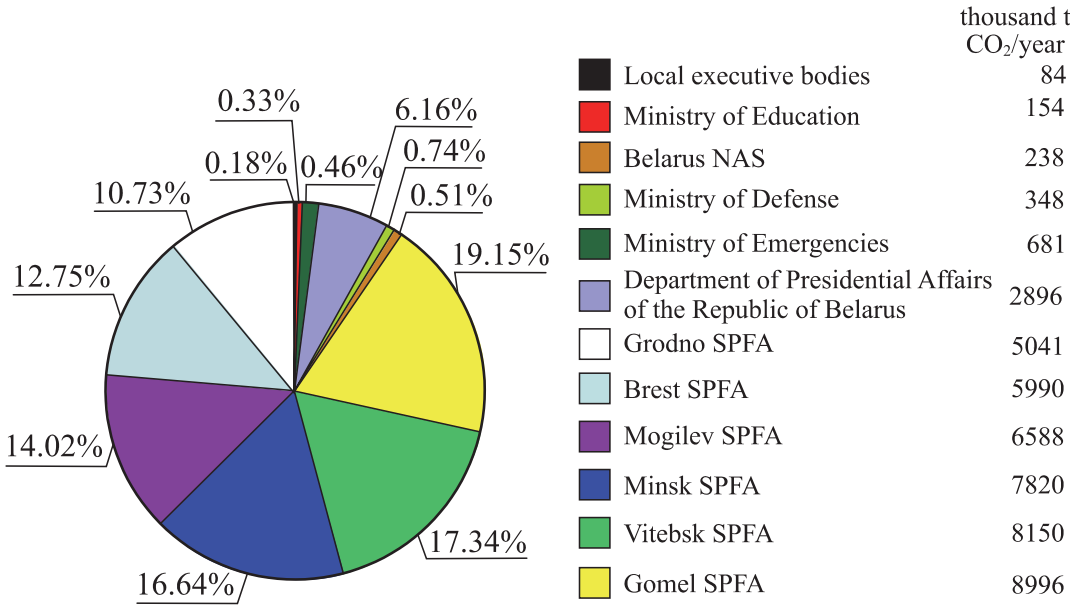

Figure 5.5. Annual CO_2 absorption by the forest fund under the ownership of governmental bodies and other agencies (L.N. Rozhkov)

Figure 5.6 outlines the predictable annual wood harvest and timber removal from forests until 2030.

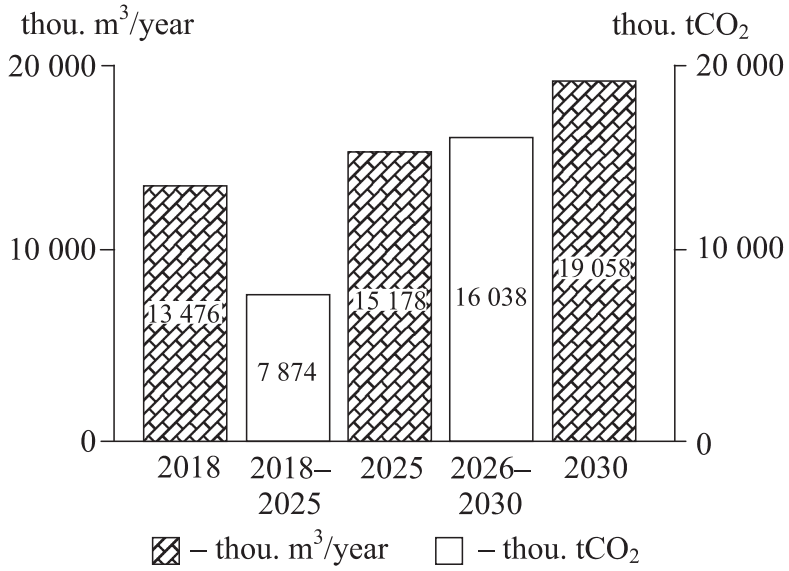

Figure 5.6. Predictable annual wood harvest and carbon dioxide "emission" in the forest fund of the Republic of Belarus (L.N. Rozhkov).

Wood harvest is estimated to increase by an average of 1,694 thousand m^3 until 2030 as compared to 2017. Consequently, the level of annual carbon dioxide absorption is expected to decrease by an average of 1,708 thousand t annually (Table 5.3, Figure 5.6).

Table 5.3

Estimated Decrease of Carbon Stock and Increase in Carbon Dioxide "Emission" in the Forest Fund of the Republic of Belarus Due to Increased Wood Harvest Volumes.

Governmental bodies and other agencies	Carbon removal through wood harvest, thousand tC			Carbon dioxide "emission" from wood harvest and transportation, thousand tCO_2	
	2018–2025	2026–2030	2018–2025	2026–2030	Total 2018–2030
Republic of Belarus	2148	4375	7874	16038	23912
Ministry of Forestry including:	2035	4107	7460	15056	22516
Brest SPFA	810	840	2970	3079	6049
Vitebsk SPFA	170	1416	623	5191	5814
Gomel SPFA	100	249	367	913	1280
Grodno SPFA	398	715	1459	2621	4080
Minsk SPFA	283	590	1037	2163	3200
Mogilev SPFA	274	297	1004	1089	2093
Office of the President of the Republic of Belarus	89	195	326	715	1041
Ministry of Defence	16	65	59	238	297
Ministry of Education	3	3	11	11	22
Belarus NAS	5	5	18	18	36

The tendency of declining of carbon stock contradicts the national policy in the field of climate change mitigation. The forest sector must compensate the CO_2 emissions from wood harvest by means of measures to increase the carbon sequestration capacity of forests. In this way, the present level of the carbon dioxide absorption will be maintained. Responsible forest management and efficient actions that can affect carbon flows can increase the level of carbon dioxide absorption by the forest fund of Belarus.

5.4. Strategy for Increasing the Absorption of Carbon Dioxide by the Forest Fund of the Republic of Belarus

Below is the list of the most important program documents outlining the forestry policy in the field of mitigation of adverse weather and climate effects by means of carbon dioxide absorption by the forest fund of the Republic of Belarus:

- Presidential Decree of the Republic of Belarus No.345 dated 20.09.2016 "On adoption of international agreement". (Accidence to the Paris Agreement of 22.04.2016).
- The State Program "Environmental Protection and Sustainable Use of Natural Resources" for 2016–2020, approved by Resolution № 205 of the Council of Ministers of the Republic of Belarus dated March 17, 2016.
- National Action Plan for Development of "Green Economy" in the Republic of Belarus until 2020. Approved by the Resolution of the Council of Ministers of the Republic of Belarus No.1061 dated 21.12.2016.
- National Strategy for Sustainable Social and Economic Development of the Republic of Belarus until 2030. Approved by the record of the meeting of the Presidium of the Council of Ministers of the Republic of Belarus No.10 dated 02.05.2017.
- Strategic Plan for Forestry Development for 2015-2030. Approved by the Deputy Prime Minister of the Republic of Belarus M.I. Rusyi No.06/201-271 dated 23.12.2014.
- State Program "Belarusian Forest" for 2016–2020. Approved by the Resolution of the Council of Ministers of the Republic of Belarus No.215 dated 18.03.2016.

For the past 65 years the forest fund of the Republic of Belarus has sequestered 2,111 million t of carbon which provided removal of 7,740 million t CO_2 from the atmosphere. Annual carbon dioxide absorption has increased 2.53 times and amounted to 46, 986 thousand t in 2017, i.e., 42% of industrial greenhouse gases emissions was compensated.

Strategic areas of the forest sector for XXI century can involve the following measures and actions:

▪ **Change of forest management in swampy forests of transition and upland types.**

Swampy forests are tree stands growing on peat-boggy soils. They represent a unique ecological system that is extremely rich in vegetation and biodiversity and is an important element of CO_2 "stock-emission" balance. The pool of swampy forests contains about 60% of the total carbon amount in the forest fund phytomass (Figure 5.7). About 40% of carbon are retained by swampy forests as peat for long-term sequestration which is crucial to the issue of greenhouse gases [39].

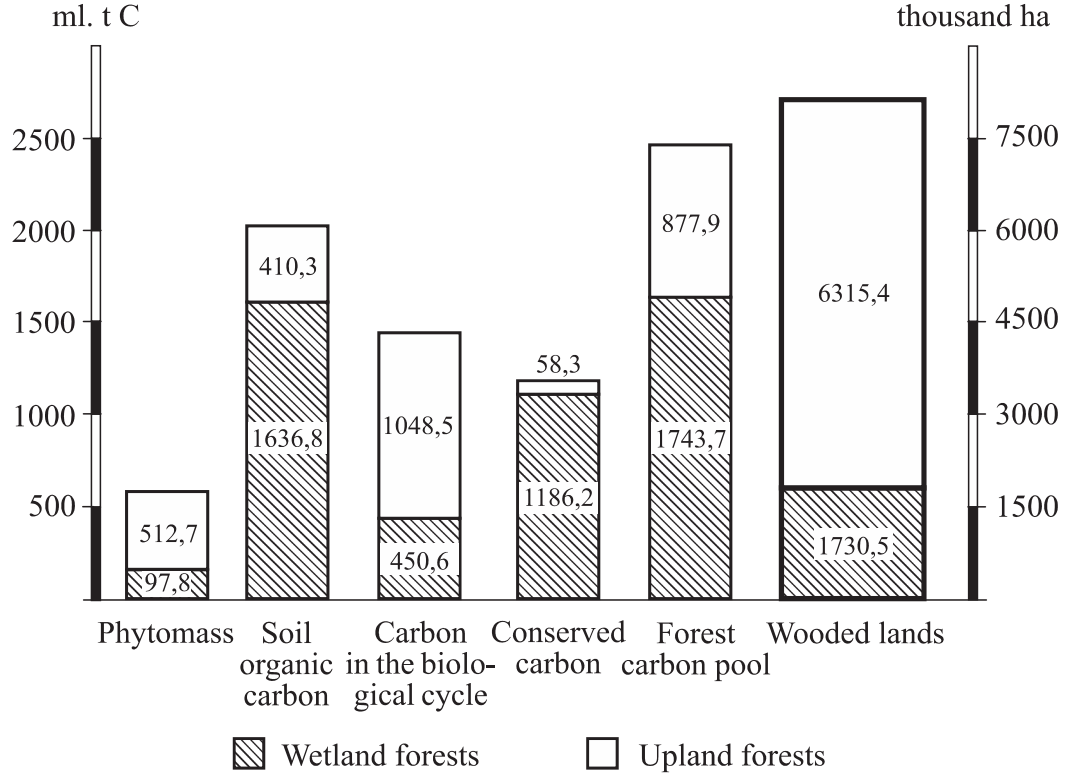

Figure 5.7. Carbon pools of wetland and upland forests in Belarus (L.N. Rozhkov)

If soil carbon is involved in the small biological cycle due to intensive peat mineralization under the conditions of forest drainage, forest cuts, soil cover damage by forestry machines, carbon dioxide can be released into the atmosphere in the amount of 2.68 t CO_2/ha/year.

Efficiency of the action. Enhanced biodiversity of forests, ecological services (tourism) continuous water protection and regulation function, prevention of carbon dioxide emission. Annual carbon dioxide absorption of +2.05 t CO_2/ha/year.

▪ **Improved effect from reforestation by application of advanced technology of planting stock cultivation and artificial forest regeneration methods.**

Annual carbon dioxide absorption of 3.30 t CO_2/ha/year can be achieved through reforestation after wood harvesting by final felling using the method of natural replacement of coniferous and deciduous forests by soft-wooded broadleaved ones (aspen, birch, grey alder) of vegetative origin, low commercial value and productivity.

Annual carbon dioxide absorption of 5.13 CO_2/ha/year can be achieved by forest plantation from ball-rooted nursery stock originated from high-quality selection seeds.

Efficiency of the action. Added annual carbon dioxide absorption of +1.83 t CO_2/ha/year.

▪ **Continuous environmental-protection function and conservation of natural components of forest ecosystem at the "felling – reforestation" stage**

Today final fellings are carried out over considerable areas of mixed coniferous-deciduous forests of natural origin, low-disturbed forests, differently-aged forests, forests with young growth, understorey, animal diversity and other components.

Methods of artificial or natural forest regeneration are used to restore typical forest landscape that has been exposed to anthropogenic impact as a result of clear cutting with the use of forestry and logging machinery. Natural reforestation is difficult to estimate under the present conditions and it seldom results in the complete restoration of the original natural landscape. Artificial forest ecosystems are more likely to lose genetic, species and landscape diversity and have degraded ecological functions. Annual carbon dioxide absorption will amount to 3.30 t CO_2/ha/year for natural reforestation and 5.13 t CO_2/ha/year for artificial reforestation.

Continuous environmental-protection function (density $\geq$ 0.6) and conservation of natural components of forest ecosystem at the "felling – reforestation" stage can be ensured through partial cuttings (gradual, voluntary-selective), ecologically sound logging technology, conservation of young growth, support for natural regeneration, care of naturally-regenerated forest (Figure 5.8). Cutting cycle is reduced by 5–7 years as compared to final felling. Annual carbon dioxide absorption amounts to 5.58 t CO_2/ha/year per a cutting cycle.

Efficiency of the action. Additional carbon dioxide absorption during non-clear cuts with preservation of undergrowth and with measures assisting regeneration will amount to +2.28 t CO^2/ha per year for a period of years for which the cutting cycle is reduced.

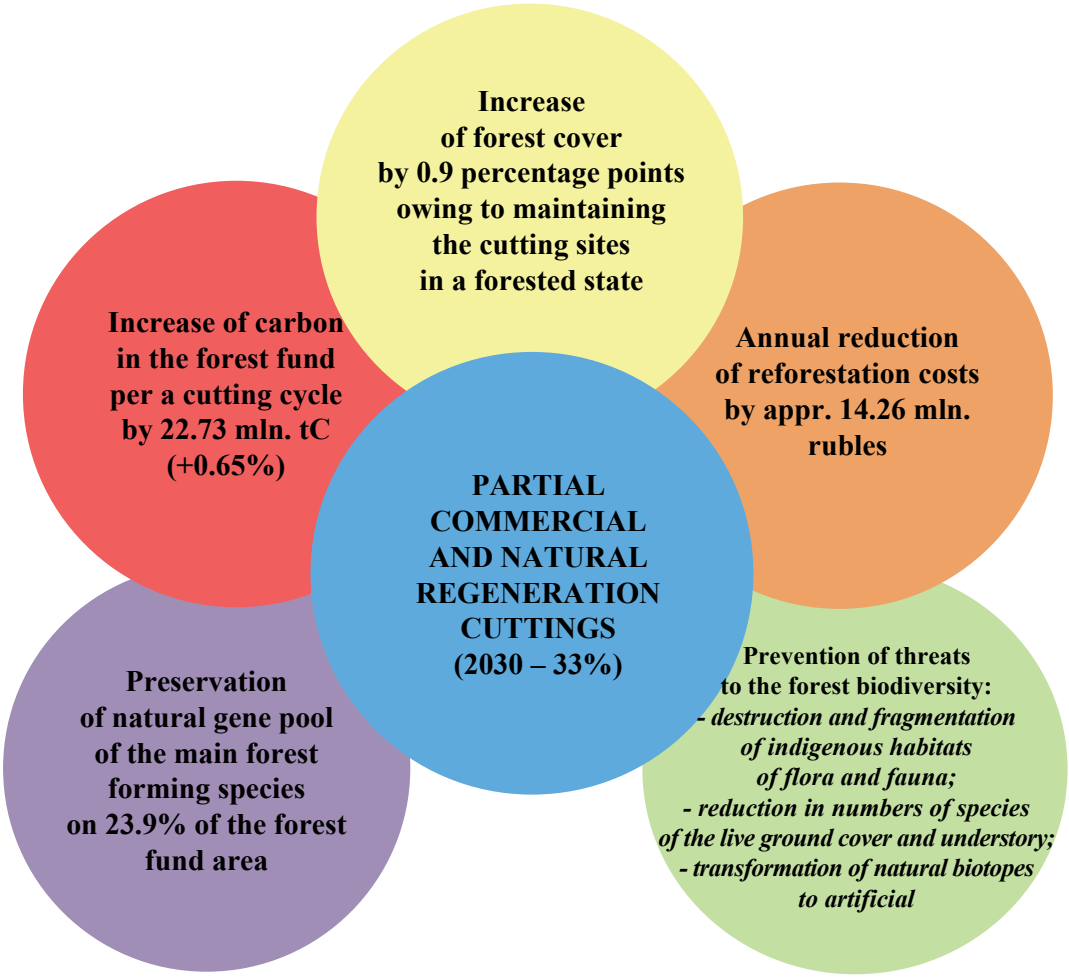

Figure 5.8. Ecological and economic efficiency of partial cuttings and natural forest regeneration (L.N. Rozhkov)

▪ **Restoration of low-grade forest stands.**

Wood harvested during reconstruction is used for energy purposes and substitutes fossil fuels (coal, oil and natural gas). If average wood volume is 60 m^3 per 1 ha of the stand under restoration, the "emission" reduction (about 86 t CO_2 /ha) will be compensated by the same reduced amount of carbon dioxide absorption.

Forest plantations created upon the restoration give the average wood increment of 3.6 m^3/ha.

Efficiency of the action. Added annual carbon dioxide absorption of +5.13 t CO_2/ha/year due to the creation of normal stands in place of low-grade and low-productive ones.

▪ **Energy uses of wood harvested from littery forest.**

Experts estimate the current increment of the Belarusian forests at 70 million m^3 per annum. About 10 million m^3 of this volume is not put into use and produces forest debris. The amount of debris is supplemented by windblown trees and stands as a result of more frequent adverse weather and climate catastrophic events. The wood harvested from the debris-strewn forests can be used for energy purposes replacing fossil fuels.

Efficiency of the action. Increase in carbon dioxide absorption compensatory to its emission amounts to 1.4 t CO_2/m^3 if wood harvested from debris-strewn forest is put to energy uses.

▪ **Energy uses of logging residues from final and other fellings.**

The use of logging residues from clear cuttings with the subsequent creation of local cultures does not have any adverse environmental impact on biodiversity and soil fertility of forest ecosystem. As a rule, the logging residues are removed from the cutting site, in order not to hinder the preparing of soils for planting of forest cultures. Being a secondary wood material used for energy purposes, logging residues replace fossil fuels (coal, oil and natural gas) and reduce greenhouse gases emissions.

Efficiency of the action. Increase in carbon dioxide absorption compensatory to its emission amounts to 1.0 t CO_2/m^3 if logging residues are put to energy uses.

▪ **Support for natural regeneration in ripening and mature stands.**

Carbon dioxide absorption can be increased by the formation of initial young growth of target tree species in the quantity of ≥4 thousand trees/ha with the height of ≥1.0 m and wood stock of ≥5 m^3/ha. This can also create necessary conditions for young forest to be formed by the year of the nest final felling (Figure 5.9).

Efficiency of the action. Increase in carbon dioxide absorption to the amount of 7.2 t CO_2 per 1 hectare of the stand where support actions on natural regeneration have been taken.

Figure 5.9. Regeneration in the "windows" of group selection cutting (V.I.Mitrofanova, 07.08.2018)

▪ **Increasing average density of stands.**

Efficiency of the action. Increasing average density (P) of forested lands raises the annual carbon dioxide absorption by forest fund in the amount of ±0,01P = ±0,0674 t CO_2/ha/year.

▪ **Long-term removal of certain forest tracts from forest management.**

The action involves conservation of carbon stock by certain forest tracts marked on the map and in the field to exempt them from forest cuts for 20–25 years (only sanitary and occasional improvement fellings are allowed).

Prospective areas for such projects are located in the zones of high-level radioactive contamination or areas of low allowable cuts with large amounts of commercially valuable ripening and medium-aged forests. In these areas exemption from final cuts will not be a radical action of forest management.

Efficiency of the action. The amount of annual carbon dioxide absorption is to be recorded. The action implies profit-making opportunities through trading of credits from carbon sequestration (carbon credits). Sustained (additional) annual absorption will amount to nearly 1.5–2.0 t CO_2/ha/year.

▪ **Forest growing on areas of unused, low-productive or low-fertile agricultural lands.**

The forest cover of the territory of Belarus comprised 39.8% as of 01.01.2017. At the same time, this cover is not uniformly distributed by administrative districts (ranging from 10.1 to 65.5%), so necessary actions should be taken on sparsely forested lands.

The areas to be forested can include non-forested areas of the forest fund, small areas of unused and low-productive agricultural lands, low-fertile and agriculturally unprofitable lands.

Efficiency of the action. Creation of forested lands on the designated areas can ensure added annual carbon dioxide absorption of +4.0 t CO_2/ha/year.

▪ **Creation of spruce plantations under low-/medium-dense medium-aged birch and pine stands (understorey plantations) in the forest types series of bracken, myrtillus, wood-sorrel and Aegopodium.**

Understorey spruce plantations form the second storey by the time of final felling of the main storey of the stand. They yield wood stock of about 90-120 m^3/ha at the age of 40–50 years, their average density being 0.5–0.6.

Efficiency of the action. Added annual carbon dioxide absorption of +3.36 t CO_2/ha/year resulting from more extensive use of solar energy and soil fertility of the forest ecosystem.

5.5. Activities of the National Action Plan on Increasing the Absorption of Carbon Dioxide by the Forest Fund of the Republic of Belarus until 2030

Activities of the National Action Plan are to be implemented within the framework of state programs of forestry development and within the limits of the allocated financial support as well as by raising extra-budgetary funds, international financial support, other legal sources. Below are the activities and the scope of work to be implemented by agencies having the right for forest management, as well as the expected results of carbon dioxide absorption by the forest fund of the Republic of Belarus, etc. (Tables 5.4–5.8)

Table 5.4

Proposals for enabling institutional environment

Activities	Implementation period, years
1. Development of the sectoral program for increasing of average density of forests	2019
2. Entry of the following data into the Forest Cadastre: – total carbon amount of the forest fund; – phytomass carbon of the forest fund; – total dynamics of carbon sequestration by the forest fund.	2025
3. Entry of the following provision into the "Regulations of determination and approval of allowable final cuts in the forests of the Republic of Belarus": – carbon weight sequestered by wood of the established allowable cut volume shall not exceed annual carbon absorption achieved by the planned targeted actions on increasing the carbon sequestration capacity of forests and non-forested lands of the forest fund.	2020
4. Supplementing forest management plans with the section "Measures on increasing the level of carbon dioxide absorption by forest fund".	2025
5. Development of TCP "Rules of calculation of greenhouse gases absorption and emission by forest fund components".	2021–2023
6. Development of databank "Swampy forests of transition and raised types that are exploitable, unsuitable for logging, used for carbon sequestration".	2019
7. Entry of the following provision into the Fellings Regulation of the Republic of Belarus: – final cuts are not allowed in swampy forests of transition and raised types used for carbon sequestration and biodiversity conservation.	2020

Forestry-related and other actions contained in Tables 5.4–5.7 enable the forest sector to maintain for the short-term the achieved, extremely high level of carbon "stock" in the forest ecosystem of Belarus, amounting to nearly forty-seven million ton of carbon annually. The current high level of annual carbon dioxide absorption can be attributed to the established age structure of forests with prevailing medium-aged stands that demonstrate maximum annual increment of carbon sequestration. Conservation of the carbon stock in the forests is also ensured by relatively low wood harvest (as compared to environmentally allowable wood harvest volumes) in the Belarusian forests due to the low share of mature stands and great emphasis of the forest conservation issues.

Table 5.5

Scope of work to implement activities on increasing the absorption of carbon dioxide

No.	Measures	Governmental bodies and other agencies	Planned scope of work by periods	
			2018–2025	2026–2030
1.	Change of forest management regime in swampy forests of transition and raised types into nature protection regime. Exemption of certain forest type series (ledum, sphagnum, sedge-sphagnum and willow) from forest cuts will eventually ensure 10% compensation of CO_2 absorption by the forest fund due to increased carbon removal in harvested wood	Republic of Belarus	220.0	238.6
		Ministry of Forestry including:	220.0	238.6
		Brest SPFA	30.9	30.9
		Vitebsk SPFA	79.6	80.2
		Gomel SPFA	30.0	30.9
		Grodno SPFA	9.5	9.5
		Minsk SPFA	35.0	48.5
		Mogilev SPFA	35.0	38.6
2.	Creation of forest plantation by closed root nursery stock will ensure 2.8% compensation	Republic of Belarus	60420	52045
		Ministry of Forestry including:	59250	51350
		Brest SPFA	7650	9480
		Vitebsk SPFA	12750	9480
		Gomel SPFA	12750	9085
		Grodno SPFA	3800	3160
		Minsk SPFA	12100	10270
		Mogilev SPFA	10200	9875
		Office of the President of the Republic of Belarus	950	550
		Ministry of Education	25	25
		Belarus NAS	19	120
3.	Non-clear commercial cuts will ensure 3.2% compensation	Republic of Belarus	29760	41430
		Ministry of Forestry including:	27280	39500
		Brest SPFA	5600	6500
		Vitebsk SPFA	1040	8000
		Gomel SPFA	1040	7500
		Grodno SPFA	3600	3500
		Minsk SPFA	8800	7500
		Mogilev SPFA	7200	6500
		Office of the President of the Republic of Belarus	2000	1500
		Ministry of Defence	320	250
		Ministry of Education	80	90
		Belarus NAS	80	90

Table 5.5 (continued)

No.	Measures	Governmental bodies and other agencies	Planned scope of work by periods	
			2018–2025	2026–2030
4.	Restoration of low-grade forest stands will ensure 2.5% compensation	Republic of Belarus	46.4	25.8
		Ministry of Forestry including:	42.3	22.4
		Brest SPFA	7.9	4.2
		Vitebsk SPFA	7.9	4.2
		Gomel SPFA	8.8	4.7
		Grodno SPFA	4.5	2.3
		Minsk SPFA	7.3	3.9
		Mogilev SPFA	5.9	3.1
		Office of the President of the Republic of Belarus	3.4	2.6
		Ministry of Defence	0.4	0.4
		Ministry of Education	0.1	0.1
		Belarus NAS	0.2	0.3
5.	Energy uses of wood harvested from littery forest will ensure 20% compensation	Republic of Belarus	1770	1770
		Ministry of Forestry including:	1560	1560
		Brest SPFA	150	150
		Vitebsk SPFA	330	330
		Gomel SPFA	350	350
		Grodno SPFA	130	130
		Minsk SPFA	320	320
		Mogilev SPFA	280	280
		Office of the President of the Republic of Belarus	170	170
		Ministry of Defence	20	20
		Ministry of Education	10	10
		Belarus NAS	10	10
6.	Energy uses of logging residues from final and other felling sites will ensure 23% compensation	Republic of Belarus	1565	3975
		Ministry of Forestry including:	1380	3800
		Brest SPFA	150	500
		Vitebsk SPFA	300	700
		Gomel SPFA	300	700
		Grodno SPFA	120	400
		Minsk SPFA	260	800
		Mogilev SPFA	250	700
		Office of the President of the Republic of Belarus	140	140
		Ministry of Defence	30	20
		Ministry of Education	10	10
		Belarus NAS	5	5

Table 5.5 (continued)

No.	Measures	Governmental bodies and other agencies	Planned scope of work by periods	
			2018–2025	2026–2030
7.	Support for natural regeneration in ripening and mature forests will ensure 2.5% compensation	Republic of Belarus	27840	26740
		Ministry of Forestry including:	26400	25700
		Brest SPFA	3200	3750
		Vitebsk SPFA	6000	4950
		Gomel SPFA	6000	4500
		Grodno SPFA	2000	4250
		Minsk SPFA	5200	4500
		Mogilev SPFA	4000	3750
		Office of the President of the Republic of Belarus	1200	750
		Ministry of Defence	100	150
		Ministry of Education	70	70
		Belarus NAS	70	70
8.	Increase of average density of stands as compared to 2017 +0,016 (2025) and +0,044 (2030) will ensure 30% compensation	Republic of Belarus	+0.016	+0.044
		Ministry of Forestry including:	+0.016	+0.044
		Brest SPFA	+0.016	+0.044
		Vitebsk SPFA	+0.016	+0.044
		Gomel SPFA	+0.016	+0.044
		Grodno SPFA	+0.016	+0.044
		Minsk SPFA	+0.016	+0.044
		Mogilev SPFA	+0.016	+0.044
		Office of the President of the Republic of Belarus	+0.016	+0.044
		Ministry of Defence	+0.016	+0.044
		Ministry of Education	+0.016	+0.044
		Belarus NAS	+0.016	+0.044
		Republic of Belarus	+0.016	+0.044
9.	Long-term withdrawal of certain forest areas from forest management will ensure 9.2% compensation of CO_2 absorption by the forest fund due to increased carbon removal in harvested wood	Republic of Belarus	30.0	200.0
		Ministry of Forestry including:	30.0	200.0
		Brest SPFA	10.0	30.0
		Vitebsk SPFA	10.0	90.0
		Gomel SPFA	10.0	80.0

Table 5.6

Expected results of the implementation of activities on increasing the absorption of carbon dioxide

Governmental bodies and other agencies	Added carbon dioxide absorption by period, thousand t CO_2		
	2018–2025.	2026–2030	Total 2018–2030
Republic of Belarus	7900.9	16301.0	24201.9
Ministry of Forestry including:	7480.2	15101.3	22581.5
Brest SPFA	1091.6	2241.7	3333.3
Vitebsk SPFA	2077.0	3796.9	5873.9
Gomel SPFA	1337.9	3412.0	4749.9
Grodno SPFA	563.7	1257.7	1821.4
Minsk SPFA	1274.6	2436.2	3710.8
Mogilev SPFA	1135.4	1956.8	3092.2
Office of the President of the Republic of Belarus	302.4	854.4	1156.8
Ministry of Defence	35.0	102.2	137.2
Ministry of Education	13.0	36.3	49.3
Ministry of Emergencies	52.0	154.0	206.0
Belarus NAS	18.3	52.8	71.1

Table 5.7

Expected values of annual carbon dioxide absorption, thousand t CO_2/year

Governmental bodies and other agencies	Years		
	2017	2025	2030
Republic of Belarus	46986	47012.9	47249.0
Ministry of Forestry including:	42585	42605.2	42630.3
Brest SPFA	5990	4111.6	5152.7
Vitebsk SPFA	8150	9604.0	6755.9
Gomel SPFA	8996	9966.9	11495.0
Grodno SPFA	5041	4145.7	3677.7
Minsk SPFA	7820	8057.6	8093.2
Mogilev SPFA	6588	6719.4	7455.8
Office of the President of the Republic of Belarus	2896	2872.4	3035.4
Ministry of Defence	348	324.0	212.2
Ministry of Education	154	156.0	179.3
Ministry of Emergencies	681	733.0	835.0
Republic of Belarus	238	238.3	272.8
Local executive bodies	84	84	84

The age structure dynamics is expected to change in the foreseeable future. Mature stands will be cut for both economic and environmental reasons. The mature stands have accumulated large carbon content over the years. However, their annual carbon dioxide absorption has a declining tendency and they become a source of carbon emission as they approach their biological age. This can be observed in old-aged forests of natural reserves and national parks.

The goal of maintaining the current level of annual carbon dioxide absorption by the forest fund can be achieved by increasing of forest productivity. The forestry-related measures proposed by the National Action Plan are very promising for this purpose. They include creation of forest plantations by root-balled nursery stock with valuable selection properties, reconstruction of low-value forest stands, reduction of cutting cycles of non-clear commercial cuts to preserve young growth and to encourage natural reforestation. These actions are a mechanism of long-term effect for increasing forest productivity. The diversified measures to increase the average density of stands are also highly promising. This issue was of little concern in the past; however, this can yield considerable wood stock increment due to improved reforestation and forest care measures.

Swampy forests occupy 18.6% of the total area and generate almost a half of the total carbon budget in the forest fund of Belarus. It is highly important to maintain and enhance the carbon sequestration capacity of swampy forests. Some of them are managed forests and their wood harvesting capacity can be increased as a result of intensive forest road construction. Mature upland forests are characterized by intensive wood increment, therefore it should be recommended to reduce wood harvesting in swampy forests. The measures of the National Action Plan aiming at reinforcing of the conservation regime in the forests are advisable and highly effective in terms of carbon sequestration and improvement of forest biodiversity.

The forest sector implements a set of measures on optimization of the age and tree species structure of forests. These issues are addressed in the expert reviews contained in this report. The effects of the changes in age and tree species structure of the Belarusian forests on the level of carbon dioxide absorption by them have been assessed and demonstrate controversial results. This is explained by the necessity of balance of economic and ecological interests and by ambiguous climate and weather impacts on the forest ecosystem of

Belarus. Age structure of forests can be changed over long periods (many decades). The ideal age structure of forest, the so-called "normal" forest and associated sustainable forest management is characterized by the level of carbon dioxide absorption that is half as much as the current level. For this reason this report does not consider the optimization of the age structure of forests to be very promising. We also do not recommend changing the existing program for the optimization of the tree species structure of the Republic of Belarus. The change in the tree species of the Belarusian forests will not affect the level of carbon dioxide absorption due to the existing balance of economic and ecological interests.

These and other measures on increasing the level of carbon dioxide absorption by the forest fund require the improvement of the institutional environment of carbon sequestration (Table 5.4).

Several regulations given in Table 5.4 should be developed within the forest sector. Among them we should mention monitoring of carbon flows through the National Forest Cadastre, recording of carbon sequestration when substantiating allowable cuts, more thorough approach towards carbon sequestration measures in the forest inventory projects. The existing guidelines on calculation of carbon dioxide absorption and emission by the forest fund of the Republic of Belarus should be updated and given the status of TCCP.

Table 5.5 describes suggested practical measures on increasing of carbon dioxide absorption by the forest fund together with the scope of work and implementation periods. As can be noted from the Table, about 94% of measures should be implemented by the Ministry of Forestry which is the main forest owner. However, other agencies having the right of forest management should also be involved in the suggested activities, their contribution becoming more essential in the future.

Due to the estimated increase in wood harvest (Figure 5.6) decreasing carbon stock and increasing carbon dioxide "emission" in the forest fund of the Republic of Belarus (Figure 5.7, Table 5.3), it is necessary to identify possible ways of compensation of the carbon dioxide "emission" estimated for 2018–2030, its amount being 23.912 thousand tCO_2. Implementation of the measures suggested by the National Action Plan (Table 5.6) provides for additional carbon dioxide absorption by the forest fund to the amount of 24.201,9 thousand tCO_2 that compensates for the estimated "emission" resulting from carbon removal due to wood harvest.

Table 5.8

Calculation of the increase in carbon dioxide absorption resulting from the target measures of the forest fund of the Republic of Belarus

Target measures	Basic values	Calculation formula
1: Change of forest management regime in swampy forests of transition and boggy types	**S_1**: Area under targeted measure **1**, [ha]. **N_1**: Duration of the record period of measure **1** under changed regime, [year]. **F_1**: Efficiency factor of targeted measure **1**, [tCO_2/ha/year]: F_1 = 2.05 tCO_2/ha/year.	**$A_1 = 2.05\ S_1\ N_1$**, where A_1 added carbon dioxide absorption through the change of swampy forests regime, [tCO_2].
2: Creation of forest plantation by closed root nursery stock	**S_2**: Area under targeted measure **2**, [ha] **N_2** Duration of the record period of measure **2** from the creation year of forest plantation, [year]. **F_2**: Efficiency factor of targeted measure **2**: F_2 = 1.83 tCO_2/ha/year.	**$A_2 = 1.83\ S_2\ N_2$**, where A_2 – additional carbon dioxide absorption through creation of forest plantation by ball-rooted nursery stock, [tCO_2].
3: Application of silvicultural system "partial cut – natural forest regeneration"	**S_3**: Area of single inventory of partial final cut after naturally regenerated forest has been transferred into the category of valuable forest stands, [ha]. **N_3**: Reduction of cutting cycle as compared to final cuts and artificial forest regeneration, [years]. **F_3**: Efficiency factor of targeted measure **3**: F_3 = 2.28 tCO_2/ha/year.	**$A_3 = 2.28\ S_3\ N_3$**, where A_3 – added carbon dioxide absorption through reduced cutting cycle of partial cuts with conservation of young growth and regeneration support measures, [tCO_2].
4: Restoration of low-grade forest stands	**S_4**: Area of the stands under restoration. Record of the area after the target has been achieved, [ha]. **N_4**: Projected period of the target achievement under measure **4** until the record year, [years]. **F_4**: Efficiency factor of targeted measure **4**: F_4 = 5.13 tCO_2/ha/year.	**$A_4 = 5.13\ S_4\ N_4$**, where A_4 – added carbon dioxide absorption through replacement of low-grade stand by more valuable one, [tCO_2].

Table 5.8 (continued)

Target measures	Basic values	Calculation formula
5: Clearing-up of forest debris with subsequent energy uses of harvested wood	$\mathbf{V_5}$: Volume of wood harvested from clearing-up of debris and used for energy purposes, [m^3]. $\mathbf{F_5}$: Factor of atmospheric carbon dioxide absorption during formation of one unit of wood debris: $F_5 = 1.4\ tCO_2/m^3$.	$\mathbf{A_5 = 1.4\ V_5}$, where A_5 – volume of replacement of greenhouse gases "emission" by carbon dioxide absorption when fossil fuels are replaced by wood harvested from debris-strewn forest, [tCO_2].
6: Use of logging residues from final cuts for energy purposes	$\mathbf{V_6}$: Volume of logging residues from final and other cuts used for energy purposes, [m^3]. $\mathbf{F_6}$: Factor of atmospheric carbon dioxide absorption during formation of one unit of logging residues: $F_6 = 1.0\ tCO_2/m^3$.	$\mathbf{A_6 = V_6}$, where A_6 – volume of replacement of greenhouse gases "emission" by carbon dioxide absorption when fossil fuels are replaced by logging residues, [tCO_2].
7: Support of natural regeneration in ripening and mature forests	$\mathbf{S_7}$: Area of ripening and mature forests under support measures for natural regeneration. Record of the area when young growth of target culture is available at ≥ 4 thousand trees/ha, height ≥ 1,0 m, wood stock ≥ 5 m^3/ha, [ha]. $\mathbf{N_7}$: Duration of the period required for the formation of sufficient young growth by the year of final cut in the original stand, [year]. $\mathbf{F_7}$: Efficiency factor of targeted measure **7**: $F_7 = 7.2\ tCO_2/ha$.	$\mathbf{A_7 = 7.2\ S_7\ N_7}$, where A_7 –level of increased carbon dioxide absorption by the forest stand with young growth, [tCO_2].
8: Increase of average density of stands	$\mathbf{P_{cur}}$: One hundredth part of one density unit of forested lands of a forestry organization in the current year. $\mathbf{P_{bas}}$: One hundredth part of one density unit of forested lands of a forestry organization in the basic year. $\mathbf{N_8}$: Duration of the study period, [years]. $\mathbf{F_{0.01P}}$: Change of annual carbon dioxide absorption by forested lands of the Republic of Belarus per one hundredth part of one density unit: $\pm 0.01P = \pm 0.0674\ tCO_2/ha$.	$\mathbf{A_8 = 0.0377\ (P_{cur} - P_{bas})\ N_8}$, where A_8 – level of carbon dioxide absorption resulting from measures on increasing the average density of forested lands of a forestry organization, [tCO_2].

Table 5.8 (continued)

Target measures	Basic values	Calculation formula
9: Long-term withdrawal of certain forest areas from forestry management.	**S_9**: Forest areas exempt from forest cuts for long-term period, [ha]. **N_9**: Period of exemption from forest cuts, [year]. **F_9**: Factor of the maintained annual carbon dioxide absorption resulting from the forest cut exemption under measure **9**: $F_9 = (1.5–2.0)$ tCO_2/ha/year. Factor F_9 is to be specifies depending on the conditions.	**$A_9 = (1.5–2.0)\ S_9\ N_9$**, where A_9 – the maintained annual carbon dioxide absorption resulting from the forest cut exemption of certain forest tracts, [tCO_2].
10: Afforestation	**S_{10}**: Area of lands transferred for forest growing, [ha]. **N_{10}**: Duration of the period starting from afforestation year to the record year, [years]. **F_{10}**: Annual carbon dioxide absorption by tree stands on the areas under afforestation: $F_{10} = 4.0$ tCO_2/ha/year. Factor K_{10} is to be specifies depending on the conditions.	**$A_{10} = 4\ S_{10}\ N_{10}$**, where A_{10} – carbon dioxide absorption by tree stands on the areas under afforestation, [tCO_2].
11: Creation of spruce forests under the storey of medium-dense medium-aged birch and pine stands (understorey plantations).	**S_{11}**: Area of understorey spruce plantations, [ha]. **N_{11}**: Duration of the period starting from plantation year to the record year, [years]. **F_{11}**: Increased level of carbon dioxide absorption due to more extensive use of solar energy and soil fertility: $F_{11} = 3.36$ tCO_2/ha/year.	**$A_{11} = 3.36\ S_{11}\ N_{11}$**, where A_{11} – added carbon dioxide absorption by forest stands through the formation of the under storey spruce plantations, [tCO_2].

The compensation of the estimated carbon dioxide “emission” is ensured by the additional (excessive) absorption owing to the following measures: increased average density of stands – 30%; energy uses of logging residues from final and other cuts – 23%; energy uses of wood collected from debris clearing – 20%; change of management regime in swampy forests – 10%; long-term withdrawal of certain forest areas from forestry management – 9.2%; partial final cuts – 3.2%; creation of forest plantation by ball-rooted nursery stock – 2.8%; restoration of low-grade forest stands – 2.5% and support for natural regeneration in ripening and mature forests – 2.5% compensation for the estimated carbon dioxide “emission”.

Table 5.7 outlines the expected values of annual carbon dioxide absorption planned for public forest management bodies and other organizations (SPFAs) in accordance with the National Action Plan. To ensure reporting and recording in line with the indicators specified in Table 5.8, methodical recommendations for calculation of the increase of carbon dioxide absorption from the target measures of the forest fund of Belarus have been proposed.

6. NATIONAL ACTION PLAN FOR INTRODUCTION OF PRINCIPLES OF THE "GREEN ECONOMY" INTO THE FORESTRY OF THE REPUBLIC OF BELARUS UNTIL 2030

6.1. General Provisions

The principles and criteria of the "green economy" developed for the forestry of the Republic of Belarus served as a basis for the Draft National Action Plan for the Implementation of the Principles of the "Green Economy" in the forestry of the Republic of Belarus until 2030 (hereinafter referred to as the National Action Plan).

The National Action Plan provides for the overall vision, goal, objectives and specific activities as well as defines prospective participants contributing to the achievement of the objectives set.

Vision of the National Action Plan. Under the conditions of the "green economy" the forest sector makes a huge contribution to human well-being by producing timber and non-timber products and services and creating revenue-generating opportunities. At the same time the forest sector maintains sustainable development of forests and their ecosystem service capacity under the climate change conditions. Forest management aims at protecting the interests of all stakeholders including rural population and forestry workers. It also ensures effective and economical use of all forest resources, facilitates climate change mitigation and provides due account of ecosystem service costs during decision-making processes.

The goal of the National Action Plan is to ensure the maximum possible contribution of the forestry of the Republic of Belarus to the development of the forming "green economy". This shall be achieved through the improved human well-being and enhanced social justice with simultaneous considerable reduction of environmental risks and scarce environmental resources.

All measures and activities of the National Action Plan shall be undertaken based on the established principles and criteria of the "green economy" for the forest sector. They are intended to reduce carbon emissions, efficient use of resources and are socially oriented.

The goal of the National Action Plan implies the following objectives:

– to ensure sustainable production and consumption of forest commodities (development and implementation of environmentally friendly and resource-efficient production technology and consumption models of timber products including waste minimizing, waste recycling and consumption of wood harvested from sustainably managed forests);

– to ensure climate change mitigation through the carbon absorption by forests and replacing nonrenewable resources and fuels by renewable wood-based materials and fuels;

– to guarantee the creation of "green" workplaces in the forest sector;

– to take actions aimed at professional development of forestry workers and workplace safety and hygiene;

– to provide ecosystem service assessment during managerial decision-making processes, including charges for forest ecosystem services and compensations to ecosystem service providers;

– to ensure justifiable decision-making based on factual data, effective tools, social justice and transparent monitoring of sustainable forest utilization.

6.2. Major National and Global Tendencies in Development of the "Green Economy" in the Forest Sector

Main prerequisites for the implementation of the principles of the "green economy" in the forestry of the Republic of Belarus are as follows:

– international commitments to transfer to the "green economy" model stated in the Declaration of the Seventh "Environment for Europe" Ministerial Conference and the "Rio+20" outcome document (The system of measures to enhance the technological capacity of the national economy to ensure its operation on the principles of the "green

economy" (approved by the Deputy Prime Minister M.I. Rusyi, No. 06/214-186 dated July 10, 2012) was developed and is being implemented);

– the Paris Agreement adopted within the United Nations Framework Convention on Climate Change on December 12, 2015 and signed by the Republic of Belarus in April 2016;

– the Rovaniemi Action Plan for the implementation of the principles of the "green economy" in the forest sector;

– the best practices of the countries demonstrating considerable advances in the "green economy" in the forest sector;

– legislative and regulatory framework developed in the Republic of Belarus for the planned implementation of the principles of the "green economy":

a) National Action Plan for the Development of the "Green Economy" in the Republic of Belarus until 2020 (approved by the Resolution of the Council of Ministers of the Republic of Belarus No. 1061 dated December 21, 2016);

b) National Strategy for Sustainable Social and Economic Development of the Republic of Belarus until 2030;

c) Development Program of the Industrial Complex of the Republic of Belarus until 2020;

d) State Program for Climate change Mitigation for 2013–2020;

e) Forest Code of the Republic of Belarus No. 332-3 dated December 24, 2015;

f) Strategic Plan of the Forestry Development in the Republic of Belarus until 2030;

g) State Program "Belarusian Forest" for 2016–2020, etc.

6.3. Principles and Criteria of the "Green Economy" for the Forestry of the Republic of Belarus

Main principles and criteria of the "green economy" developed for the forestry of the Republic of Belarus are presented in Table 6.1.

It should be noted that the criteria and corresponding actions for Principle 5 "Development of forest ecosystem services" can be implemented with financial support by international funds, the World Bank, private investment and other extrabudgetary resources.

Table 6.1

Principles and criteria of the "green economy" for the forestry of the Republic of Belarus

Principles	Criteria
1	2
1. Resource-efficient and sustainable utilization of forest resources	1.1. long-term planning of all types of forest utilization; 1.2. utilization and extraction of forest resources considering the needs of future generations; 1.3. implementation of environmentally friendly and low-waste technologies of wood harvesting and processing; 1.4. production of high added value commodities; 1.5. use of low-quality firewood, logging and sawing waste for energy purposes and other needs of the economy (power industry, agriculture, etc.); 1.6. use of energy-effective and environmentally friendly power units and fuels in the forest sector; 1.7. use of non-timber forest resources.
2. Conservation, protection, development and climate change adaptation of forests, increasing their level of greenhouse gases absorption	2.1. development of forest resources, increasing the forest productivity, their climate change adaptation; 2.2. long-term planning of measures on forest resources regeneration with estimation of environmental risks and development of the set of measures to minimize losses associated with such risks; 2.3. maintenance of proper sanitary state of forests and forest ecosystem resilience; 2.4. conservation and restoration of the biological diversity of forest ecosystems; 2.5. maintenance of environmental isolation of the forest ecosystems contaminated by radionuclides; 2.6. conservation and enhancement of the protective functions of forests; 2.7. increasing the level of greenhouse gases absorption by forests.
3. Strong social policy and high living standards due to the development of the forest sector and nature management	3.1. positioning of the forestry as a key industry of the national economy; 3.2. creation of green jobs; 3.3. higher prestige of the forestry-related professions; 3.4. development of forestry education; 3.5. increased employment and well-being of people; 3.6. support and development of the social sphere of the forest sector.

Table 6.1 (continued)

Principles	Criteria
1	2
4. Increasing the international influence of the Republic of Belarus as a "green country"	4.1. contribution of research and manufacturing sector of economy to national and international forest science; 4.2. compliance of the national plans and strategies with international commitments assumed in the field of the "green economy"; 4.3. enforcement of national legislation and regulatory acts; 4.4. increased public awareness of the contribution of the Belarusian forest sector to climate change mitigation in Europe; 4.5. development of inbound tourism in the regions of Belarus that are rich in cultural and natural attractions.
5. Development of forest ecosystem services	5.1. development and promotion of ecological tourism; 5.2. governmental support and easy-term loans for legal entities and individual entrepreneurs rendering tourism-related services in protected nature areas; 5.3. creation of ecotourism clusters; 5.4. development of a compensation mechanism for forest ecosystem services.

6.4. Activities of the National Action Plan for Introduction of the Principles of the "Green Economy" into the Forestry of the Republic of Belarus

The following set of measures will contribute to the implementation of the principles of the "green economy" in the forestry of the Republic of Belarus.

1. Modernization of the forestry and logging production, increasing of their efficiency and competitiveness; creation of conditions for service market development (see criteria 1.3, 1.6, 3.2, 3.5).

The creation of new forestry and logging enterprises and modernization of the existing ones can be based on the up-to-date knowledge-intensive technology and equipment. This together with the development of domestic high-performance machinery and the purchase of the foreign analogues will make it possible to increase

labour productivity, to minimize injury risks, to reduce operating costs and to mitigate anthropogenic environmental impact. Engagement of private companies in forestry and logging operations will allow to improve the quality of the work performed and to reduce its costs.

Efficiency of the actions: improved efficiency of forestry and logging production, creation of "green" jobs, mitigation of anthropogenic environmental impact.

2. Manufacturing of high added-value products (see criteria 1.3, 1.4, 1.5, 3.1, 3.2, 3.3, 3.5, 3.6).

Development of saw-milling and woodworking production, increased output of dried timber, increased production volumes of fuel wood chips, pellets and briquettes.

Efficiency of the action: multipurpose use of wood resources, improved performance of forestry enterprises, creation of high-performance "green" workplaces, increased employment and human well-being.

3. Use of low-grade firewood for energy purposes (see criteria 1.2, 1.3, 1.5, 1.6, 3.2, 3.5).

Using the capacity of forests for energy purposes by means of replacing fossil fuels by local renewable wood resources is an important point of the "green economy" as this reduces greenhouse gas emissions into the atmosphere, facilitates carbon sequestration during the development of forest stands, gives a boost to the regional development through upgrade and development of infrastructure of logging and wood fuel supply and creates a lot of high-performance workplaces.

The country implements a set of measures aimed at the extended use of local fuels on an ongoing basis. The measures taken have made it possible to use local energy resources on a larger scale and to increase their share of boiler and furnace fuels from 16.8% to 26.4% for the past 8 years. At the same time the share of renewable energy sources amounted to 8.3% with dominating wood fuel. This use of renewable energy sources is now less capital-intensive and more cost-effective. However, the government has set a strategic task to achieve the minimum 32% share of domestic energy resources in the total energy balance for heat and power generation by 2020. To achieve this objective the use of low-grade firewood takes a considerable part.

Efficiency of the action: reduced anthropogenic environmental impact, increased energy and economic safety of the country, reduced imports, more intensive regional development, creation of "green" jobs.

4. Use of logging waste from wood harvest during final and other cuts (see criteria 1.2, 1.3, 1.5, 1.6, 2.3, 3.2, 3.5).

The volume of firewood harvest has amounted to 6–6.5 million m^3 over the recent years. Considerable amount (about 3.6 million m^3 or 55–65%) of the firewood harvest is sold to households, municipalities, public organizations. Thus, the remaining 3 million m^3 of firewood can be used or is being used by boilers and CHP plants to generate power and heat.

At the same time logging waste which is another major resource has only very limited use. Considerable amounts of logging waste are produced during final fellings, intermediate and other cuts. Certain amount of the logging waste should be left in the forest for biodegradation to avoid future uses of mineral fertilizers. Some logging waste is used to reinforce skid roads on waterlogged areas. At the same time many experts consider that as much as 50% of the logging waste can be used for technological and energy purposes without any substantial harm to the environment.

It has been estimated that in Belarus about 600–800 thousand solid m^3 of logging waste can be used for energy purposes.

Efficiency of the action: comprehensive use of wood raw materials, waste-free technology, improved clearing of felling areas, reduced risks of forest pests attacks and forest diseases. Reduced anthropogenic environmental impact, improved economic and energy safety of the country, reduced imports, more intensive regional development, creation of "green" jobs.

5. Rational utilization of non-timber resources (see criteria 1.7, 3.2, 3.5).

Development and implementation of measures aimed at comprehensive use of non-timber resources can be done by allocating special resource zones (areas) for commercial harvest of mushrooms and berries in the forest fund. Such areas can be given the status of ecological tourism zones. Forestry operations in the areas should be implemented with due regard to their high value as areas of primary importance for harvesting mushrooms and berries both by local population and specialized farms dealing with harvesting and processing of wild berries and mushrooms.

The specialized units should be created under the forestry enterprises that are rich in berries, mushrooms and medicinal herbs and are located in rural areas where harvesting of non-timber forest products is a traditional activity. To increase the efficiency of forest

fund lands unsuited to forest growing, berry and mushrooms plantations can be created.

Efficiency of the action: more extensive comprehensive use of forest ecosystems, improved efficiency of forestry operations, creation of "green" jobs, increased employment and human well-being.

6. Construction of forest roads (see criteria 1.1, 1.3, 2.1, 2.3, 2.4, 2.6).

Undeveloped road network causes economic accessibility of forest resources together with incomplete harvest of felling areas and is a deterrent to the improved performance of the forestry operation. Mature and overmature wood is left in the forest. Such wood loses its mechanical properties and is not commercialized thus incurring losses to the forest sector.

The total density of the road network in the forest fund of the Republic of Belarus which can be used all year round is 0.23 km per 100 hectares of the total area. This goes to prove insufficient transport development of the forested lands. In Latvia this index equals to 1 km per 100 hectares, in Northern Europe – 3 km, in the Federal Republic of Germany – 3.6 km.

The road network must be extended due necessity to perform the annually increasing prescribed cuts, timely forest regeneration operations, forest pest and diseases control, extinguishing of forest fires.

The volume of forest roads construction to be implemented by the Ministry of Forestry (as many as 100 kilometres per annum) is established in Clause 10 of the Protocol of the Instructions of the President of the Republic of Belarus Mr.A.G. Lukashenko, dated June 14, 2006, during the meeting concerning the improvement of efficiency of forestry and woodworking industries held on September 07, 2006, No.15.

Efficiency of the action: increased wood harvest volumes, reduced transportation costs, possibility to undertake forestry operations all year round, timely road and nature protection actions and measures of pest and fire control. The extension of road network will lead to the improved economic efficiency of other industries and higher level of services rendered to the population.

7. Forest management based on the principles of maintaining sustainability of forest ecosystems (see criteria 1.2, 2.1, 2.4, 2.6, 3.1, 4.2, 4.3).

To ensure continuous ecological functions of forest ecosystems, they should be managed by the principles of sustainability. This can be

achieved through the commitment to forest management principles that match the requirements of international forest certification standards. At present a considerable number of forestry enterprises have certificates of conformity to the principles of FSC forest certification, however, the national standard of FSC management has not yet been approved in Belarus.

Efficiency of the action. Development, consideration and implementation of the national standard of voluntary FSC forest certification will make it possible to adapt the forest management system to modern requirements of forest management guided by the principles of biodiversity conservation as a basis for forest systems sustainability.

8. Support for natural regeneration in ripening and mature forest stands (see criteria 2.1, 2.2, 2.4, 2.6, 2.7).

Formation of initial new growth of target species to the quantity of ≥4 thousand pcs/ha as tall as ≥1.0 m and having volume of ≥5 m^3/ha leads to increasing of carbon dioxide absorption and formation of young growth during the year when the final cut is made.

Moreover, preliminary and concurrent natural regeneration makes it possible to reduce the cutting cycle and to improve the efficiency of utilization of forest fund lands. Stands formed by natural young growth assist to biodiversity conservation of forest ecosystems, create better opportunities for secondary forest utilization and ecological tourism.

Efficiency of the action. Increasing of carbon dioxide absorption, conservation of biological and genetic diversity of forest ecosystems, preservation of capacity of the forest areas as ecological tourism sites and secondary forest utilization.

9. Increased average density of stands as compared to 2017 (see criteria 2.1, 2.2, 2.4, 2.6, 2.7).

The action will make it possible to increase the volume of commercial wood harvest by the time the stands have reached the final cut age. The wood will have better qualities as compared to that harvested during intermediate cuts. The action will also result in higher amount of profit per one unit area of forested lands as well as in increasing of the level of carbon dioxide absorption by forest stands.

Efficiency of the action. Increased average density of forested lands leads to higher volumes of commercial wood harvest per one unit area and increases the carbon dioxide absorption by forest fund to the amount of ±0,01P = ±0,0674 t CO_2 per annum.

10. Restoration of low-grade forest stands (see criteria 1.1, 1.5, 2.1, 2.2, 2.3, 2.7).

Restoration of low-grade forest stands will increase the output of commercial wood coming from more valuable tree species. The wood harvested during the restoration can be used for energy purposes.

Additionally, forest plantations created after the restoration will enable wood stock increment as much as 3.6 m^3/ha thus increasing the carbon dioxide absorption.

Efficiency of the action. Increased output of commercial wood coming from more valuable species, increased employment of local population, supplementary wood fuel and increased annual carbon dioxide absorption + 5.13 t CO_2/ha/year.

11. Switch of the forest management regime in swamp forests to conservation regime. Withdrawal of the following forest type series from wood harvest: ledum, sphagnum, sedge-sphagnum and willow (see criteria 1.7, 2.4, 2.6, 3.1, 4.4, 4.5, 5.1, 5.3).

Swamp forests are forest stands growing on peat-boggy soils. These forest ecosystems are unique nature communities playing a highly important role in sustainable activity of the biosphere. One of their key functions is habitat-forming, i.e., swamps and swamp forests provide habitats for more than 40% of birds, 35% of insects and more than 15% of red-listed wild plants. Swamp forests possess rich biological reserves of cranberries and medicinal herbs. Management of these ecosystems will negatively affect their capacity of rendering the ecosystem services.

Efficiency of the action. Increased biodiversity of forests, preservation of their habitat-forming and water-conservation functions, ecotourism services, mitigation of greenhouse gases emissions.

12. Long-term withdrawal of certain forest areas from forest management (see criteria 2.4, 2.5, 2.6, 2.7, 4.3, 4.4, 4.5, 5.1, 5.2, 5.3).

The action should be implemented on the forested lands belonging to the forestry enterprises located in radiologically contaminated regions with large areas covered by medium-aged, ripening and mature stands. Such stands have a structure that is similar to that of climax communities of high biological diversity. Long-term lack of anthropogenic impact will give rise to flora and fauna communities that have a structure and biogeocenotical relations similar to the natural ones. Such communities are highly valuable in terms of ecotourism development. Exemption of one or two age classes from final felling will not have a dramatic effect on forest management.

Efficiency of the action. Increased biological diversity of forests, supplementary greenhouse gases absorption, opportunities for ecotourism development.

13. Extending the forest fund areas that are monitored by remote early fire detection systems (see criteria 2.2, 2.3, 2.4, 2.6).

Climate change effects require a combined (monitoring and automated detection) system of tracking and early detection of forest fires by remote sensing. The system uses video surveillance tools of departmental fire towers and posts, telecommunication towers and other tall structures to ensure maximum coverage of the monitored forest fund areas.

Efficiency: reduced environmental, social and economic losses from forest fires, maintenance of protective functions of forests.

14. Extending the forest fund areas under forest pathology research, including remote sensing (see criteria 2.1, 2.3, 2.4, 2.6).

Climate change has major negative effects on sanitary state of forests and reduces the level of greenhouse gases absorption. Data of forest pathology monitoring by remote sensing can improve the efficiency of the actions aimed at localizing and eradicating forest diseases and pests centres as well as ensure prompt sanitary measures taken in forests.

Efficiency of the action. Reduced environmental, social and economic losses incurred by forest pests and diseases, improved quality and quantity parameters of forest stands; improved research and methodological, information and economic support and development of an efficient system of environmental risk management in the forest sector; optimization of budget allocation to preventive and remedial actions.

15. Development of information support system of the environmental risks assessment in the forest sector through creating a databank of forest mortality cases due to various factors across forestry enterprises (see criteria 1.1, 1.2, 2.1, 2.2, 4.1, 5.4).

According to the data of monitoring the area of lost forest stands amounts to about 13 thousand hectares annually. Main factors causing the mortality are adverse weather effects (78% of the total area of lost forest), forest fires (10.8%) and forest pests and diseases (6.7%).

In 2016 the forest pathology condition in Belarusian forests dramatically declined compared to 2015. Various adverse abiotic and biotic factors caused death of 27220.9 ha of stands that is twice as much as in 2015 whereas primarily coniferous stands (89.9%) suffered from these negative effects. The highest death rates were registered in Minsk

State Production Forestry Association (14189 ha) amounting to 52.1% of the total area of all lost stands in the Republic of Belarus in 2016.

The recent development of the forest fire-fighting system caused reduction of forest fires (in terms of the number of fire outbreaks and the fire-affected areas) in spite of the general aggravation of weather and climate conditions and forest-fire situation. It should be noted, however, that general overview of the harmful effects and their impacts can only be made with the data of minimum 10-year period.

Shift to the "green economy" will require effective tooling provided at the governmental level. Such tooling will make it possible to assess social and economic losses from environmental hazards in the forest sector.

Efficiency of the action: increased information support to assess environmental hazards in the forest sector.

16. Development and approval of a methodology "Procedure for economic assessment of environmental hazards in the forest sector": adverse weather conditions, forest fires and diseases (see criteria 1.1, 2.1, 2.2, 4.1, 5.4).

Based on the expert estimates and reviews of stands mortality dynamics over the recent 10 years, the average annual losses, including the costs of recovery operations, have amounted to: losses from forest fires – 1 613 USD/ha per annum; losses from adverse weather conditions – 131 USD/ha per annum; losses from forest pests and diseases – 94 USD/ha per annum. The total costs of environmental and economic losses in the national forest sector have averaged 3.7 million USD/year, including costs of recovery operations.

Mitigation of negative effects from hazards and uncertainty can only be possible with scientific-based methodology for economic assessment of environmental hazards and their effect on ecological and economic aspects of nature management. The category of environmental hazards comprises not only potential economic losses but also possible decrease in nature resource capacity as a basic factor of human well-being. Economic assessment of environmental hazards must be based upon the calculation of natural capital losses to estimate damage (monetary value of damage) caused to the environment and human well-being with due regard to probability of such damage.

Efficiency: increased level of scientific and methodological support and development of an efficient system of environmental hazards management in the forest sector.

17. Formulation of proposals to create a mechanism for environmental hazards management in the forest sector based upon preventive technical actions, post-disaster recovery operations and economic tools (insurance, optimized funding of preventive measures, record of risk assessment in terms of stumpage value, etc.) (see criteria 1.1, 1.2, 2.2, 5.4).

Changing climate conditions, expected forest fire hazards, development of forest diseases and pests and increased wood harvest and recreational utilization of forests require the improvement of methods and facilities of forest protection. Such methods should include development and implementation of automated video surveillance systems, using of pheromones, biopreparations, in-depth study of pathological processes and pests development.

A major task of the "green economy" under climate change adaptation is to reduce the probability of factors leading to forest mortality as well as to ensure mitigation of environmental damage and negative effects on forest ecosystems in case the negative factors are in place.

Adverse factors occur intermittently, i.e., 2–3 times over a ten-year period. Such situation requires development and implementation of an effective mechanism of risk management that would involve technical measures, recovery operations, their optimized funding based on the economic assessment of environmental hazards, record of risk assessment in terms of stumpage value and creation of insurance reserves to compensate the losses occurred during the most dangerous years.

Efficiency: reduced environmental risks in the forest sector, including minimized losses and probability of their occurrence.

18. Promotion and support to national forest science and education (see criteria 3.3, 3.4, 4.1, 4.4).

Further development of the Belarusian forest science and education can be supported by research projects aimed at the development of new technologies and machinery, engagement in international projects, organization of exhibitions, forums and conferences involving foreign scholars and experts, improvement of curricula and educational courses to train professionals that are capable of meeting challenges of the "green economy".

Efficiency of the action. Following the world trends of forestry development, study of international best practices, accelerated implementation of advanced technology, machinery and equipment, support to the national machine-building industry, improved quality of education and professional development of forestry professionals.

19. Conservation and utilization of biological diversity of forest ecosystems in a sustainable way (see criteria 1.1, 1.2, 1.3, 1.5, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6).

It is necessary to keep a register of protected nature areas, to identify key habitats of rare and valuable flora and fauna in order to integrate them into the protected areas. Biological diversity is known to be one of the most important resources of regional ecotourism development.

Ecological tourism is a mechanism that both attracts cash flows to the wildlife-rich areas and raises people's awareness of conservation of these untouched nature areas. Ecological tourism can be an effective tool of biodiversity conservation in natural ecosystems.

Mature and overmature stands usually demonstrate the highest biodiversity and are the most attractive ecotourism spots. Such stands are approaching the stage of a climax community with well-developed biogeocenotic layers. Nemoral species are particularly valuable as they are associated with unique communities of broadleaved forests due to negative natural processes and anthropogenic load. These stands are most important for biodiversity conservation and development of ecological tourism therefore they should be listed as unique biotopes after thorough adequate investigation. In this way they can be exempt from final cuts and conserved as unique natural complexes.

Efficiency of the action. Conservation of forest ecosystems important to biodiversity conservation will enhance the capacity of forest enterprise areas as ecotourism destinations.

20. Development of a web portal devoted to ecological tourism in Belarus (see criteria 3.1, 3.2, 3.3, 3.5, 4.4, 4.5, 5.1, 5.3).

The web portal shall publish information and promotional content about ecological routes and excursions (ecological trails, tourist camps, watch towers, open-air cages, etc.) and licensed tour guides in several languages.

The web portal can be used as a communication platform for tour operators, hotels, health and holiday centres, national parks and reserves, individual tourists. It should contain information on licensing rules for tour guides as well as on various contests and promotional offers for its visitors.

Efficiency of the action. Raising public awareness of ecosystem services provided by the Belarusian forests, natural attractions and recreational opportunities of Belarus; holiday-planning services for domestic and international travelers; increased competition and service quality in the ecotourism industry; increased employment and human well-being.

21. Allocation of forest stands with good ecotourism capacity, their integration into ecological routes and trails (see criteria 3.1, 3.2, 3.5, 4.4, 4.5, 5.1, 5.3).

In order to develop ecological tourism and to market the region as one of the most attractive for international tourists, it is necessary to make this destination popular first of all with the residents of Belarus. Such approach will create conditions for the development of the domestic ecotourism market and will serve as the best promotion to international visitors. This will require the development of ecotourism infrastructure (ecological routes, tourist facilities, watch towers, open-air cages, etc.).

Forest ecosystems of high biological diversity are key components of ecological trails and routes. The quality of the related actions can be improved by allocating such ecosystems and creating their databanks.

Efficiency of the action. Improved efficiency of secondary utilization of forest ecosystems through ecotourism development.

22. Marketing and promotion of tourist services rendered by forestry enterprises, creation of additional workplaces in the "green economy" sector (see criteria 3.1, 3.2, 3.5, 4.4, 4.5, 5.1, 5.3).

To create demand for the tourist facilities that are available or being created by forest enterprises, a number of actions should be undertaken, i.e., appropriate description of the tourist facilities, texts of excursions, checklists of excursions and tours, registration of the tourist facilities with the National Tourism Agency. These actions will require from forest enterprises to institute the staff position of specialist in tourism and nature management. Therefore a prospective range of tourism service consumers can be widened and additional workplaces in the "green economy" sector can be created.

Efficiency of the action. Improved efficiency of secondary utilization of forest ecosystems through the promotion of ecotourism services in the domestic and international markets.

23. Study and discussion of a compensating mechanism for ecosystem services with stakeholder community (see criteria 1.1, 1.2, 2.1, 2.2, 3.1, 3.5, 4.2, 4.4, 5.4).

Currently TCP 17.02-10-2013 (02120) "Environmental protection and nature management. Procedure for the monetary evaluation of ecosystem services and biological diversity" is effective in the Republic of Belarus. The TCP makes it possible to evaluate ecosystem services rendered by forests to people and organizations.

Ecosystem services are benefits provided by natural ecological systems to cater for various social and ecological needs of the population. Forest enterprises of the country make sure that forest ecosystems continue to render their services. The costs borne by the forest enterprises can be compensated in several ways. As of today it is most advisable to reduce the associated tax burden. In this way the society proves to be willing to compensate for the expenses to the organizations engaged in rendering the ecosystem services.

Efficiency: generation of additional sources to finance the actions aimed at conservation and expansion of the ecosystem services provided by forests.

The measures of the National Action Plan shall be taken within the framework of state programs for forestry development within the limits of the budget allocated hereto, as well as by raising extrabudgetary funds, international financial support and other legal sources of funding.

Main actions on improvement of the institutional framework for the implementation of the principles of the "green economy" in the forestry of the Republic of Belarus are given in Table 6.2.

Table 6.2

Actions on improvement of the institutional framework for the implementation of the principles of the "green economy" in the forestry of the Republic of Belarus

Action	Implementation period, years
1. Improvement of legislative, regulatory and methodological framework to produce wood fuel, its harvest and storage, including onsite actions on forest fund areas	2019–2025
2. Development and implementation of the national standard of FSC-based forest certification. Improvement of the standards of national forest certification as required by PEFC	2019
3. Improved information support to assess environmental risks in the forest sector through creating a databank of forest mortality cases due to various factors across forest enterprises	2020
4. Development and approval of a methodology "Procedure for economic assessment of main environmental hazards in the forest sector": adverse weather conditions, forest fires, pests and diseases	2023
5. Formulation of proposals to create a mechanism for environmental hazards management in the forest sector based upon preventive technical actions, post-disaster recovery operations and economic tools (insurance, optimized funding of preventive measures, record of risk assessment in terms of stumpage value, etc.)	2030

Table 6.2 (continued)

Action	Implementation period, years
6. Entry of the following provision into the "Rules of Forest Felling in the Republic of Belarus": – final cuts are not permitted in swampy forests of transition and high-bog types that are used for biodiversity conservation and carbon sequestration	2020
7. Recording data on forest stands valuable to ecotourism development in forest inventory projects	2025
8. Creation of the databank "Swampy forests used for recreation, ecological tourism and carbon dioxide sequestration"	2020
9. Development of proposals on a compensating mechanism for ecosystem services provided by forests	2020

The scope of work to be carried out within the actions aimed at the implementation of the principles of the "green economy" in the forestry of the Republic of Belarus until 2030 are given in Table 6.3.

Table 6.3

Scope of work within the activities aimed at the implementation of the principles of the "green economy" in the forestry of the Republic of Belarus

No.	Activities	Governmental bodies and other agencies	Scope of work by implementation periods	
			2018–2025	2026–2030
1.	Modernization of the forestry and logging production, increasing their efficiency and competitiveness; creation of conditions for service market development: – use of multi-operation machines (harvesters) for felling operations when harvesting felling-area resources, % of the total wood harvest: • clear cuts • partial cuts – regular workshops on efficient cutting methods and forest regeneration	Ministry of Forestry	 75 4 +	 80 10 +

Table 6.3 (continued)

No.	Activities	Governmental bodies and other agencies	Scope of work by implementation periods	
			2018–2025	2026–2030
2.	Manufacturing of high added-value products	All forest fund holders	+	+
3.	Use of low-quality firewood for energy purposes, thousand m^3	Republic of Belarus	53471	34845
		Ministry of Forestry including:	50054	32620
		Brest SPFA	5179	3375
		Vitebsk SPFA	10582	6896
		Gomel SPFA	11475	7478
		Grodno SPFA	4208	2743
		Minsk SPFA	10107	6587
		Mogilev SPFA	8503	5541
		Office of the President of the Republic of Belarus	2690	1750
		Ministry of Defence	245	160
		Ministry of Education	181	120
		Belarus NAS	301	195
4.	Energy uses of logging residues from final and other felling sites, thousand m^3	Republic of Belarus	1725	3125
		Ministry of Forestry including:	1600	3000
		Brest SPFA	166	310
		Vitebsk SPFA	338	634
		Gomel SPFA	367	688
		Grodno SPFA	135	252
		Minsk SPFA	323	606
		Mogilev SPFA	272	510
		Office of the President of the Republic of Belarus	125	125
5.	Rational utilization of non-timber resources	All forest fund holders	+	+
6.	Forest road construction, km	All forest fund holders	700	500
7.	Forest management based on the principles of maintaining sustainability of forest ecosystems	All forest fund holders	+	+

Table 6.3 (continued)

No.	Activities	Governmental bodies and other agencies	Scope of work by implementation periods	
			2018–2025	2026–2030
8.	Support for natural regeneration in ripening and mature forests, ha	Republic of Belarus	27840	26740
		Ministry of Forestry including:	26400	25700
		Brest SPFA	3200	3750
		Vitebsk SPFA	6000	4950
		Gomel SPFA	6000	4500
		Grodno SPFA	2000	4250
		Minsk SPFA	5200	4500
		Mogilev SPFA	4000	3750
		Office of the President of the Republic of Belarus	1200	750
		Ministry of Defence	100	150
		Ministry of Education	70	70
		Belarus NAS	70	70
9.	Increase of average density of stands as compared to 2017	All forest fund holders	+0,016	+0,044
10.	Restoration of low-grade forest stands, thousand ha	Republic of Belarus	42,6	25,8
		Ministry of Forestry including:	38,5	22,4
		Brest SPFA	6	4,2
		Vitebsk SPFA	6	4,2
		Gomel SPFA	8,8	4,7
		Grodno SPFA	4,5	2,3
		Minsk SPFA	7,3	3,9
		Mogilev SPFA	5,9	3,1
		Office of the President of the Republic of Belarus	3,4	2,6
		Ministry of Defence	0,4	0,4
		Ministry of Education	0,1	0,1
		Belarus NAS	0,2	0,3

Table 6.3 (continued)

No.	Activities	Governmental bodies and other agencies	Scope of work by implementation periods	
			2018–2025	2026–2030
11.	Change of forest management regime in swampy forests into conservation regime. Exemption of certain forest type series (ledum, sphagnum, sedge-sphagnum and willow) from forest cuts, thousand ha	Republic of Belarus	220,0	238,6
		Ministry of Forestry including:	220,0	238,6
		Brest SPFA	30,9	30,9
		Vitebsk SPFA	79,6	80,2
		Gomel SPFA	30,0	30,9
		Grodno SPFA	9,5	9,5
		Minsk SPFA	35,0	48,5
		Mogilev SPFA	35,0	38,6
12.	Withdrawal of certain forest areas from forest management, thousand ha	Republic of Belarus	30,0	200,0
		Ministry of Forestry including:	30,0	200,0
		Brest SPFA	10,0	30,0
		Vitebsk SPFA	10,0	90,0
		Gomel SPFA	10,0	80,0
13.	Expansion of forest areas monitored by remote early fire detection systems, % of the forest fund area	All forest fund holders	40	50
14.	Increasing of the forest fund areas under forest pathology research, including remote sensing, thousand ha, not less than	All forest fund holders	1 500	2 000
15.	Development of information support system of the environmental risks assessment in the forest sector through creating a databank of forest mortality cases due to various factors across forestry enterprises	Republic of Belarus	+	
		Ministry of Forestry including:	+	
		Brest SPFA	+	
		Vitebsk SPFA	+	
		Gomel SPFA	+	
		Grodno SPFA	+	
		Minsk SPFA	+	
		Mogilev SPFA		+
		Office of the President of the Republic of Belarus		+
		Ministry of Defence		+
		Ministry of Education	+	

Table 6.3 (continued)

No.	Activities	Governmental bodies and other agencies	Scope of work by implementation periods	
			2018–2025	2026–2030
16.	Development and approval of a methodology “Procedure for economic assessment of environmental hazards in the forest sector”: adverse weather conditions, forest fires, pests and diseases	Ministry of Forestry		+
17.	Formulation of proposals to create a mechanism for environmental hazards management in the forest sector based upon preventive technical actions, post-disaster recovery operations and economic tools (insurance, optimized funding of preventive measures, record of risk assessment in terms of stumpage value, etc.)	Ministry of Forestry	+	
18.	Promotion and support to national forest science and education	All forest fund holders	+	+
19.	Conservation and utilization of biological diversity of forest ecosystems in a sustainable way	All forest fund holders	+	+
20.	Development of a web portal devoted to ecological tourism in Belarus (content development and upgrade)	State enterprise “National Tourism Agency of the Republic of Belarus”, all forest fund holders	+	+
21.	Allocation of forest stands with good ecotourism capacity, their integration into ecological routes and trails	All forest fund holders	+	+
22.	Marketing and promotion of tourist services rendered by forestry enterprises, creation of additional workplaces in the “green economy” sector	Ministry of Forestry including:	28,0	49,0
		Brest SPFA	5,0	9,0
		Vitebsk SPFA	4,0	10,0
		Gomel SPFA	5,0	9,0

Table 6.3 (continued)

No.	Activities	Governmental bodies and other agencies	Scope of work by implementation periods	
			2018–2025	2026–2030
		Grodno SPFA	5,0	6,0
		Minsk SPFA	5,0	10,0
		Mogilev SPFA	4,0	5,0
		Office of the President of the Republic of Belarus	1,0	1,0
		Ministry of Defence		1,0
		Ministry of Education	1,0	
		Brest SPFA	1,0	
23.	Study and discussion of a compensating mechanism for ecosystem services with stakeholder community	Ministry of Forestry	+	

7. THE LONG-TERM FORESTRY DEVELOPMENT STRATEGY OF THE REPUBLIC OF BELARUS WITH LOW GREENHOUSE GAS EMISSIONS UNTIL 2050

7.1. General Provisions

Task 4 “Development of the Draft Long-Term Forestry Development Strategy of the Republic of Belarus with Low Greenhouse Gas Emissions until 2050” is a finishing document among the earlier developed strategies and national action plans on adaptation of the forestry of Belarus to climate change, increase in absorption of greenhouse gas emissions, introduction of the “green economy” principles (Figure 7.1).

The elaboration of the Long-Term Forestry Development Strategy of the Republic of Belarus with Low Greenhouse Gas Emissions until 2050 (hereinafter the Strategy) is based upon the working hypothesis of the formation of a low-carbon forest management system aimed at forest stock extension and sustainable production of forest ecosystems. The latter is based on national activities aimed at climate-oriented change in forest species composition and age structure of forests, their dynamics of reproduction, greening of main and intermediate forest management, silvicultural policy, and regulation of absorption processes and emission of greenhouse gases based on annual growth-cut ratio, implementation of ideology, principles and tools of "green" economy.

In this Strategy, the main aspect of action is sustainable forest management oriented towards low level of greenhouse gas emissions in terms of formation of new forestry economy and its development tools.

Greenhouse gas emissions in forestry are the annual removal of biological mass from forest ecological systems resulted from all types of cuts, logging and utilization as well as its transformation into carbon dioxide and other greenhouse effects caused by the life cycle of products from forest resources.

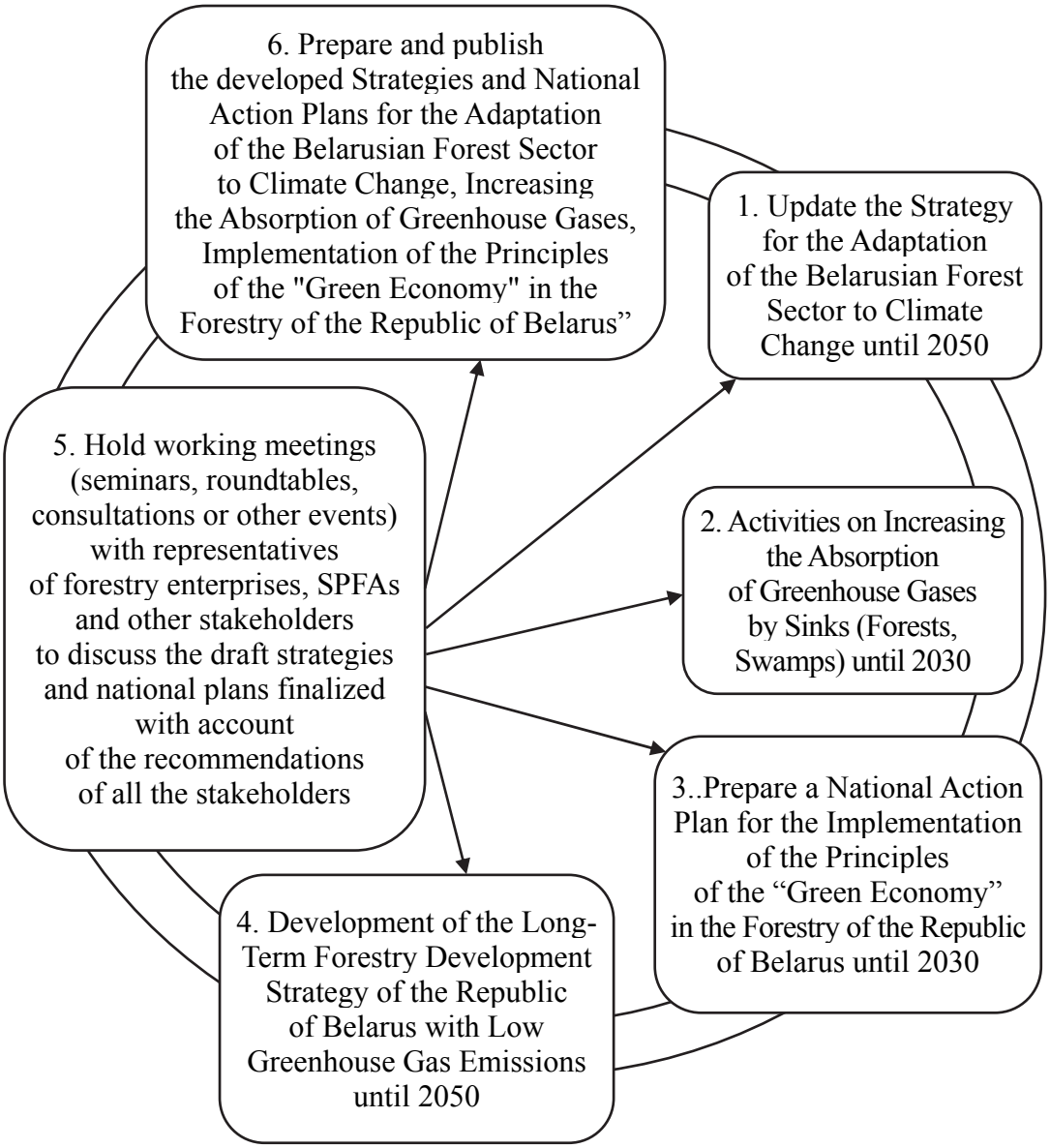

Figure 7.1. Interconnection between the stages of the project
Source: Internally developed.

The key provisions for the Strategy are:

– the emission of carbon from wood harvested from principal and regeneration cuts is compensated by adequate extent of atmospheric carbon dioxide absorption by forests;

– the mass of carbon deposited in the annual volume of hauling of timber harvested from the cuts of all types should not exceed a year's absorption in the carbon dioxide equivalent by forested or deforested forestry fund lands.

– continuous, permanent and sustainable forest management along with a system of earmarked climate-oriented activities provides low-carbon forestry development in the long term;

– the principles of rental economy of forestry and "green" vector of its development reflecting the interests of low-carbon forest management and its high income.

The Paris Agreement (Agreement) adopted in December 12, 2015 at the conference of the parties to the United Nations Framework Convention on Climate Change (COP-21, Paris, France) and endorsed by the representatives of 195 states of the world [42], aims at strengthening global response to the threats of climate change in terms of sustainable development. After 2020, the Paris Agreement will replace the Kyoto Protocol [43], based only on emissions of greenhouse gases obligations in developed countries.

In accordance with Decree of the President of the Republic of Belarus No.345 dated September 20, 2016, the Republic of Belarus became a Party to the Paris Agreement [44] and, as a Party to the Agreement, it develops and implements its own national activities to prevent climate change.

According to the State Greenhouse Gas Cadastre, in 1990 greenhouse gas emissions amounted to 139,151.23 thousand tons in CO_2 equivalent, excluding the "Land Use, Land Use Change and Forestry" Sector (hereinafter "LULUCF").

In line with the Paris Agreement, the Republic of Belarus assumes obligation to ensure reduction of greenhouse gas emissions by 2030. This reduction will be not less than 28% of the emissions' level of 1990 without taking into account emissions and sinks of greenhouse gases in the "Land Use, Land Use Change and Forestry" sector and without any supplementary conditions (the obligation does not imply the use of mechanisms of international carbon market and attraction of foreign financial resources for the introduction of the best available technologies). According to the forecasts developed by the scientists of Belarus, after 2030 it will be possible to observe the further tendency for the increasing greenhouse gases emission with passing of its peak in 2035 (Figure 7.2). But taking into account additional activities on reduction of carbon intensity of the national economy, the undertaken obligations (decrease by 28% in comparison with 1990) will be fulfilled.

Approaches of admission of «LULUCF» sector to these obligations will be defined after the detailing of methodological issues of

assessment of emissions and absorption of greenhouse gases in this sector. Not later than in 2020 the Republic of Belarus will return to an issue of admission of this sector to the obligations.

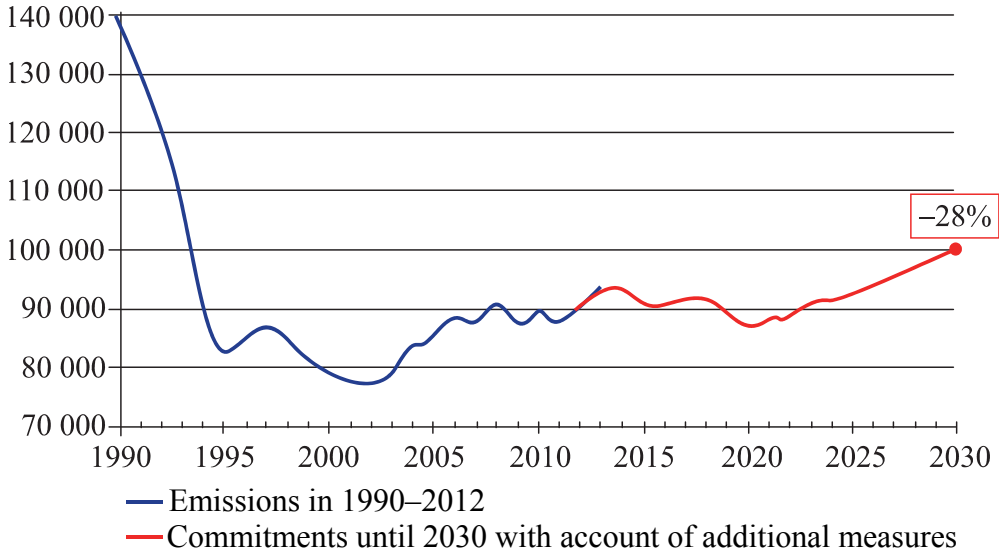

Figure 7.2. Greenhouse gas emissions in 1990-2030, Gg of CO_2 equivalent
Source: According to paragraphs 13 and 14 of Decision 1/CP.20 of the Conference of the Parties to the UNFCCC

The general reference point in the solution to the considered problem is the National Strategy of Sustainable Social and Economic Development of Republic of Belarus until 2030 [44] that considers the principles and trends of development based on low-carbon economy.

During this period it is important to formulate legislative fundamentals of new national climatic policy that will guide the creation of development programs of key economic activities for 2021–2030, including measures on regulating and stimulating reduction of greenhouse gas emissions.

7.2. Challenges of the Climate-Oriented Forestry Development

In the solution of climatic problems forestry is distinguished by its specifics and seminal role. Climate change prevention actions corresponding to national terms represent a set of specific actions and

political decisions directed to transfer of national forestry to a low-carbon sustainable development pathway.

From a standpoint of the long-term low-carbon forestry development and the current challenges in forestry practice, the forest management system is of particular importance, as well as its development towards the increase in share of mature forests, ecologization of fellings and creation of equal "economic" access to forest resources.

The significant excess of the annual increment of the timber stock over the annual volumes of forest use, that have been observed in recent decades, is a favorable ecologically oriented trend in the development of forestry in Belarus (Figure 7.3). In the future, the excess of the annual increment of the timber stock over the annual volumes of forest use must be sustained.

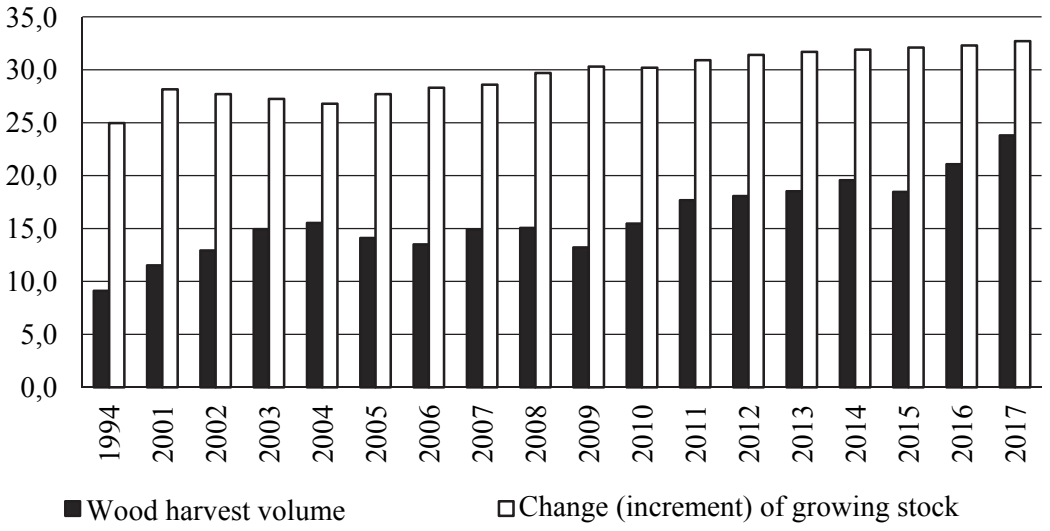

Figure 7.3. Ratio of change (increment) in growing stock and wood harvest volume in the Republic of Belarus, mln. m^3
Source: Based on the data of the Ministry of Forestry of the Republic of Belarus

The sufficient areas of ripening and middle-aged stands allow bringing the age class composition of Belarusian forests closer to optimal in 20–30 years. It affords ground for transfer to a normal wood cutting area or to a cutting area of uniform forest use.

The approximate calculations based on a cutting area of uniform forest use demonstrate: the ideal norm of long-term and permanent forest management cannot exceed 25 million m^3 at mature forests productivity with no more than 250 m^3/ha and 30 million m^3 at mature

forests productivity with 300 m^3/ha. In total, the amount of all types of cuts should not exceed the amount of annual forest growth.

According to predictive assessments, the total amount of timber harvesting can reach 27.32 million m^3 and will be regulated by the level of annual growth. The growth value can range from 25-30 mln.m^3 depending on management and increase in degree of stand density.

Other types of cuts can adjust the level of final cutting and intermediate yield as a response to natural disasters (windfalls, fires, etc.). The experience of the last years confirms the considerable allowable cuts. Based on the above, the actual allowable final cut can vary from year to year and be defined allowing for environmental risks – probabilistic damage caused to forestry, which gives the grounds to reduce the planned final cutting and intermediate yield to allowable forced cuts of other types (as it was in 2016–2017).

The dynamics of allowable cuts until 2050 is shown in Figure 7.4.

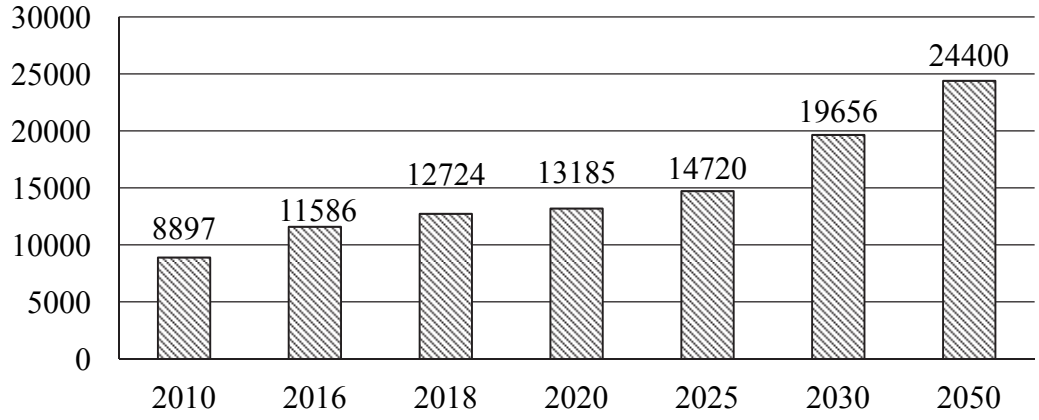

Figure 7.4. Allowable cut for final fellings until 2050, thousand cu. m
Source: Internally developed on the basis of data
of the Ministry of Forestry of the Republic of Belarus

The strategy of reasonable forest management as well as its greening in combination with a set of effective tools for regulation of sustainable development of forestry allows to keep the main ecological proportions of forest resources reproduction within a normal wood cutting area. The ecological proportions are stipulated by the equivalent between the amount of wood growth (biomass) and that of its cutting.

The positive tendency is confirmed by the share of mature forests which is going to stabilize at the level of 18–22% by 2050, thus ensuring achievement of sustainable yield level (Figure 7.5).

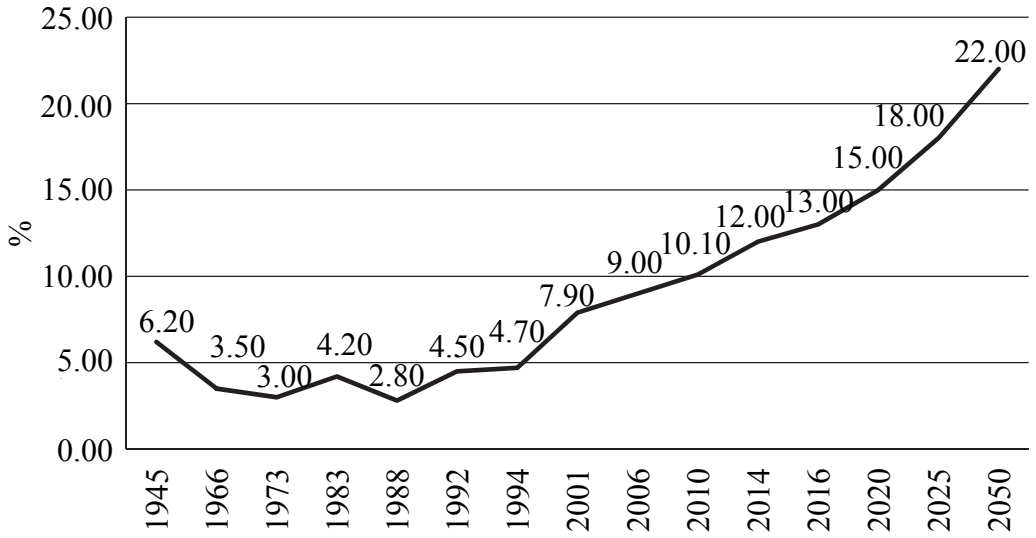

Figure 7.5. Share of mature forests in the Republic of Belarus (by area)
Source: Internally developed on the basis of data
of the Ministry of Forestry of the Republic of Belarus

Taking into account that forests with difficult accessibility will remain in the future and in view of the existence of marsh and other ecosystems (greenhouse gas sinks) in the forest fund, there is every reason to observe in the future exceeding of carbon dioxide absorption process over the process of its emission (through adherence to the principles of sustainable forest management).

This concept is the major condition of the climate-oriented long-term development of forestry of the Republic of Belarus.

7.3. Goals Framework

The main structural elements of the Strategy are the system of goals and the system of measures for their achievement.

From the position of system analysis and the development of strategic decisions, the consideration of forestry as a factor of the climate stabilization becomes politically significant.

Climate-oriented forest policy is the policy expressing ecological (and also global) value of the woods of a certain state and providing their steady reproduction in the conditions of uncertainty of climate change and increase of environmental risks. Climate – oriented forest policy is not just strengthening of actions of forestry concerning

climate change. This is its new role and historical place in the solution of global environmental problems. Successful advance in this direction cannot stay out of the international consensus and interest including economic (financial and economic) aspect.

Realization of climate – oriented forest policy causes formation of adequate forestry. Climate – oriented forestry is a natural and economic (ecology and economic) system based on priorities and values of steady environmental management, "green" economy as well as GHG emission reduction by forests, working practices for their productivization, reduction of environmental risks, methods of steady reproduction of natural capital and profitable forest management.

Considering the ecological nature of climate - oriented development of forestry, it is reasonable (when considering ecological issues) to use the terms "climate – oriented" and "environmentally friendly" as synonyms.

The formation of the climate-oriented forestry system should be carried out in the context of the current Strategic Plan for the Development of the Forestry Sector for the Period from 2015 to 2030 [12, 40], taking into account the necessary adjustments, expressing new values of strategic goals and mechanisms (tools) for achieving them.

In the current Strategic Plan for the Development of the Forestry Sector for the Period from 2015 to 2030 [12, 40], the strategic goal is defined as follows: the formation of highly productive and sustainable forests, the conservation and effective use of their biological and landscape diversity with regard to climate change and interests of "green economy", a multi-level and integrated management system based on scientific achievements, equipment and new technologies, the growth of general professional culture of forestry workers, increase of forestry profitability and economic independence, the expanded reproduction of high-quality wood for various purposes and non-timber forest products for total national economy satisfaction, social and economic development of rural areas and the creation of new jobs on the basis of small business in the sector of logging, wood processing and ecotourism.

A new emphasis elaborates the above definition by the system of goals of climate-oriented forestry development. These goals are determined by the formation of a carbon-efficient natural and economic system that ensures sustainable production of forest fund lands and high-profit functioning of economic entities.

Strategic aim and objectives are classified as:

1. General strategic climate-oriented goal.
2. Special climatic goals.
3. Climatic tasks of sustainable development of forestry.

The overall strategic climate-oriented goal is expressed in the need to form a carbon-efficient natural and economic system that ensures sustainable production of forest fund lands and high-profit functioning of the economic entities based on:

– strict regulation of annual increment and allowable cut to observe the balance of absorption and emission of greenhouse gases; ensuring long-term carbon deposition in forest pools and its sequestration by the forest fund lands;

– formation of highly productive and sustainable forests, conservation of their biological and genetic diversity, taking into account climate change and adaptation to it, increasing the contribution of forest ecosystems to global carbon cycles;

– development of a multi-purpose and integrated management system in the context of forestry yield increase and realization of "green economy" interests, scientific and practical achievements, the growth of general and professional culture of forestry workers, as well as promotion of the development of rural areas and creation of new jobs with the help of small business in the sector of logging, woodworking and ecotourism.

Special climatic goals (vector of objectives) for the long-term development of the forestry sector of the Republic of Belarus with low greenhouse gas emissions for the period up to 2050 ensure (Figure 7.6):

– adaptation of forestry to climate change;

– increase of atmospheric carbon dioxide absorption by the forest fund;

– sustainability of long-term carbon deposition in forest pools and its sequestration by forest lands;

– formation of an effective system for the decrease of carbon dioxide emission into the atmosphere in forestry.

Each of the goals contains certain content and is determined by a set of specific tasks, the solution of which is stipulated in The Strategy for the Adaptation of the Belarusian Forest Sector to Climate Change until 2050, National Action Plan on Increasing the Absorption of Greenhouse gases by Sinks (Forests, Swaps) until 2030, National Action Plan for the Implementation of the Principles of the "Green Economy" in the Forestry of the Republic of Belarus until 2030.

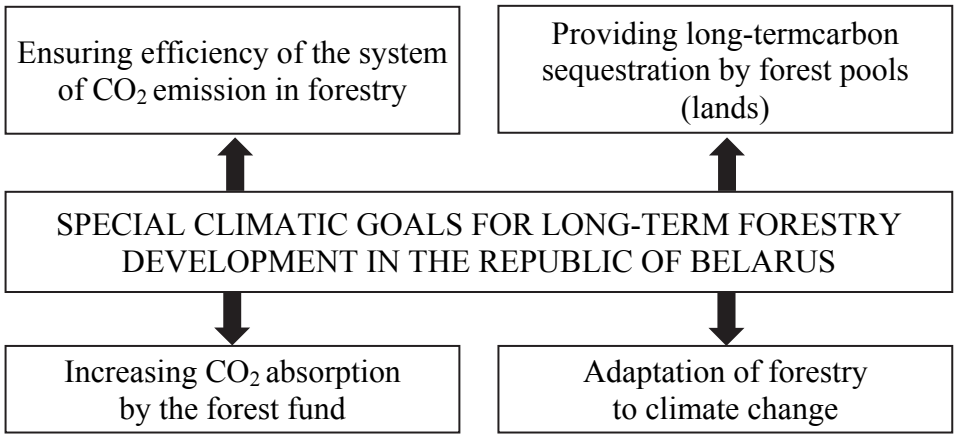

Figure 7.6. Special climatic goals
Source: Internal development

7.4. System of Activities

The goals framework is implemented through a system of activities that can be divided into:

1. Activities on adaptation of forest sector to climate change.
2. Activities aimed at contributing of forest sector into the solution to climate problem.

The principle measures to increase the adaptive potential of forest ecosystems are determined by The Strategy for the Adaptation of the Belarusian Forest Sector to Climate Change until 2050 and stipulate:

1. To increase the proportion of natural forest regeneration in reforestation process and promote its closer cooperation with artificial forest regeneration.
2. To increase the percentage of partial cuts providing the possibility to form uneven-aged forest stands and affect positively the territory forest cover.
3. To form actively mixed plantations based on growing of valuable species undergrowth, secondary species and directed intermediate cutting.
4. To use the method of partial forest plantations combining the advantages of natural and artificial forest regeneration.
5. To cultivate the system of population seed farming.
6. To create mixed forest plantations as a basis for sustainable plantations of artificial origin.
7. To increase the cultivation volume of common oak with a closed root system in the Mogilev region.

8. To justify the limits of growing area for new species and kinds of wood. In Belarus, European beech, European pine and durmast oak can belong to such species.

9. To save valuable gene resources of forest plantations. To increase the resources of genetic reserves, the area of which currently occupies no more than 0.06%. It should be natural forests, including nature oriented, recreational and protective forest stands.

10. To continue the work on creating clone banks for plus and elite trees. The clone banks should be located close to the growing area of parent plants.

11. To select local populations resistant to negative effect of climate change. Primarily it has to be done in areas with massive drying-out of plantations. Selected populations must be actively used in seed farming.

12. To reduce the risk of forest fires through early detection of fire source.

The main actions on the contribution of forestry to the solution of the climatic issue, developed within the National Action Plan on Increasing the Absorption of Greenhouse gases by Sinks (Forests, Swaps) until 2030 include the following:

1. The system of measures to increase the absorption of atmospheric carbon dioxide by the forest fund:

1.1. the improvement of the reforestation system based on the use of modern achievements in genetics, breeding and biotechnology:

– cultivation of planting material for reforestation on the basis of innovative technologies, taking into account modern achievements in the field of forestry seed collection and storage, new fertilizers, growth stimulants, plant protection products and integrated mechanization of work;

– growing of planting material of microclonal origin;

– taking measures to promote natural forest regeneration in maturing and mature stands, the formation of advance undergrowth of target species for the young growth stand in the year of final felling;

– improvement of artificial forest reforestation, creation of forest plantations through seedlings with a closed root system;

– the priority in the formation of mixed plantations with a wide range of indigenous species and shrub species tested by forest cultivation practice;

– creation of pure forest crops in the areas where natural regeneration of associate spices is sufficient;

– regulation of introduced tree species application in afforestation and reforestation on forest fund lands;

– keeping balance between natural and artificial forest regeneration and afforestation;

1.2. actions for reducing forests fragmentation; the formation of forests with improved productivity, sustainability and conservation value, increment of average density of forest-covered lands:

– afforestation of non-forest areas of the forest fund, increase of the forest cover of the territory of the republic due to afforestation of unused and low-fertile agricultural lands, as well as lands of other categories;

– optimization of the use of drained and disturbed lands as a result of the development of non-metallic minerals;

– preservation of biological and genetic diversity of forests and forest landscapes, reconstruction of subsidiary crops;

1.3. development of a system of scientifically based silvicultural measures and eco-technologies for preservation of ecological functions of forests, optimization of species and age composition of forest stands, conservation of biological diversity:

– the formation of high productive plantations through improving of forest growing technologies, intermediate cuttings, reconstruction of subsidiary young forest growths and middle-aged soft-leaved forest stands;

– implementation of priority measures for improving of plantations productivity and increment of timber reserves.

2. The system of measures for ensuring sustainable long-term carbon deposition in forest pools and its sequestration by forestlands:

2.1. optimization of the system of specially protected natural areas (SPNA) in accordance with the scheme for rational distribution of SPNA of the national importance and regional schemes for the rational distribution of SPNA of local importance, development of sustainable forest management practices in these areas in order to ensure sustainable forest management;

2.2. formation of an environmentally friendly management schedule for forestry sector in wetlands to ensure long-term sequestration of soil carbon, enhancement of biodiversity of marsh forests, environmental services supply in the form of tourism, maintenance of water conservation and water regulation role of forests;

2.3. exclusion of forest plantations located on the territories of radiation pollution from long-term forest use in order to ensure sustainable long-term carbon deposition preserving the role of forests

as a biogeochemical barrier preventing the entry of radio nuclides into adjacent territories;

2.4. exclusion from forest use for a specified period (20–30 years) of forest stands with a low allowable cut having significant reserves of middle-aged and ripening plantations usable to perform function of carbon sequestration;

2.5. gradual increase of felling age up to 90–100 years in exploitable forests having coniferous plantations with the availability of sufficient amount of areas and stock of mature tree stands.

3. A set of actions for creation of effective system to reduce the emission of carbon dioxide into the atmosphere:

3.1. definition of major lines to optimize the parameters determining final yield and to forecast their changes until 2050; the development of methods for the organization of timber harvesting and possible solutions to main problems of forest management in Belarus: optimization of species composition and age structure of forests, felling age; methods for calculating allowable final cut;

3.2. modernization of logging production to ensure its ecological efficiency, conservation and operational landscape restoration after logging, conservation of natural components of the forest ecosystem at the stage of "cutting-forest regeneration";

3.3. the use of partial cuts (gradual and voluntary-selective felling), ecologically friendly felling technology, preservation of advanced undergrowth during felling, promotion of natural forest regeneration, stimulation of accompanying reafforestation, maintenance of natural forest regeneration;

– improvement of logging processes contributing to the formation of natural forest, application of felling methods and technologies maintaining the ecological functions of forest plantations;

– rational use of forest plantations growth and regulation of attrition;

3.4. development of an effective system of protection of the forest fund; creation of a multi-level highly effective system of modern ecologically safe methods and means of preventive maintenance, early detection and rapid liquidation of forest fires, crisis phenomena, illegal logging and other forest disturbances providing a significant reduction in their scale and size of the caused economic and environmental damage:

– development of a system of economically effective and environmentally friendly measures based on advanced scientific achievements to protect forests from harmful organisms;

– strengthening control over the spread of invasive species of pests and pathogens;

– improvement of the sanitary state of forests and enhancement of biological stability of forest plantations.

The proposed system of measures is based on an integrated approach stipulated by the need: to increase the absorption of atmospheric carbon dioxide by the ecosystems of the forest fund; to ensure sustainable long-term carbon sequestration in forest pools and its sequestration by forest fund lands; to establish an effective system to reduce the emission of carbon dioxide into the atmosphere.

7.5. Transition to the 'Rental' "Green Economy" in Forestry

The leading factor in achieving desired goals and the implementation of the developed measures is the economic factor based on effective management.

The concept of modern and prospective transformations of the forestry economy is to strengthen the legal status of the forest enterprise as an establishment with the separation of independent entrepreneurial structures, but generally oriented at rental income - income expressing the nature of forestry as a sector of the national economy and at the same time as a structural element of the ecological sphere.

In this regard, the role of cadastral valuation of forests and that of entire evaluation procedure based on forest rents and the procedure for its reproduction and seizure is growing. The development of such a procedure is the most urgent task of forestry science and practice. Belarusian State Technological University has explored the theoretical and methodological foundations of evaluation procedure development. For its adaptation and implementation, it is necessary to have the national will based on the choice of the organizational model of development and aimed at strengthening and approving rental relations of sustainable forest management and the reproduction of forest capital.

The structuring of performance management in forest conducted by the Ministry of Forestry of the Republic of Belarus [41], points to the simultaneously growing role of both the forest management and forest business in the sustainable development of forest sector. Market

methods orientation boosts the economy of forestry, especially in terms of providing logging services on a competitive basis [12].

In this respect the most urgent issue is to organize civilized trading of timber at exchange auctions, which takes into consideration equal access to the raw material, actual needs of the bidders, their financial capacities, legal and economic accountability for non-collecting the declared annual contract volumes. Organizing of the civilized trading, which should be conducted in advance, will allow the forest enterprises to work on order, to plan actual volumes of logging with account of the future sales, to reduce non-manufacturing costs and to raise the level of financial self-efficiency.

In this context, the issue of price for timber and that of for standing wood is very challenging, because the level of the price affects the evaluation of result and effectiveness of forest management. An adequate price for wood (the experience of Finland, Poland) solves both economic and ecological problems of forestry development. However, such a (high) price is possible only in conditions of high-tech and competitive woodworking and other types of high value added industries. Low prices for wood raw materials highlight the weakness of the economy and the need for its thorough modernization.

In recent years, purposeful and productive work has been conducted in Belarus with involvement of large financial resources into the forest economy transformation. According to the expectations of the Government, in the nearest future the national forestry complex will be characterized by the accelerated rates of development and significant structural changes in favor of industries with added – value wood processing.

Being developed at the given stage, the high-tech economy of the forest complex indicated by market prices for wood raw materials will allow ensuring transformation processes happening in forestry sector and improve its financial situation. This circumstance does not exclude the target budget financing of forestry activities. Until the loss-free wood industry gets real, which ensures coverage of the forestry's costs by own (forestry’s) incomes, it is not reasonable to cancel state financing of forestry activities (forest enterprises).

It is important to emphasize that in case the forestry economy does not experience positive changes dictated by the spirit of the times and objective economic interests, in 2050 forecast year, forest sector will remain unprofitable in terms of its forestry activity, and the share of its

own funds will even decrease. It is possible to improve this situation through competitive, external market oriented production with added-value timber processing, its volume and quality.

The determining factor in the growth of efficiency and competitiveness of forest products is price. Only the dominant market prices for wood raw materials will ensure the necessary profitability of forestry and improve its financial position.

In addition, relying upon the analysis of the main tendencies in forest management, it is justifiable to state that Belarusian forests have been transformed from a predominantly economic resource into a social and economic resource that satisfies the expanding diverse needs in the products and benefits of the forest (as evidenced by the new version of the Forest Code) [45]. In this aspect, the role of intersectoral cooperation with organizations and structures of the environmental and social spheres, agriculture and local people is being strengthened.

With the formation of new trends in consumption of forest resources, the processes of transformation the resource-based industry into the infrastructure industry have started. Within the framework of infrastructure development of forestry, it is necessary to distinguish between ecological and social aspects [46].

Forestry as an element of environmental infrastructure of society is closely connected with satisfying of ecological needs (timber condition of area, habitat forming functions of forest, etc.).

Forestry as an element of social infrastructure of rural areas should be associated with a tourist product, a network of recreational and tourist services, the construction of landscape estates, their "green" arrangement, hunting, etc.

There is a need to develop a project for the development of the "green economy" of forest regions based on cultural concept of model forest and landscape planning involving leading scientists, designers, experts, the public.

The main problem of strategic reforms is to define the superiority institutions and procedures of the forest management system expressing the interests of forestry over the forest business system at simultaneous efficiency and competitiveness growth of the latter.

Based on social and economic principle of the formation and implementation of forest policy and the main factors of sustainable forestry development, the following clusters for the formation of key indicators should be singled out:

– economic – it expresses financial interests of the industry, its incomes and expenses;

– social – it expresses the level of well-being of forestry workers, the possibility of their spiritual and cultural development;

– ecological – it expresses the growth of productivity and sustainability of forests, including maturing and mature forests; conservation of biodiversity, climate adaptation of forestry; production of ecosystem services;

– national economic – it expresses total benefits necessary for cultural development of people and the most complete satisfaction of society diverse needs.

According to forecast calculations, the volume of sales of forestry products in perspective (2030) will increase by almost 3.5 times in comparison with 2013, the wages – by 2.7 times, while the increment of forest capital will be about 20 %, and the ecosystem services will increase by 1.3 times. This trend expressed in constant prices indicates the absolute increment of natural capital and ecosystem services meeting the conditions for a strong sustainability of development supported by economic growth and the achievement of social goals.

According to the National Strategy for Sustainable Development until 2030, (NSSD-2030) GDP growth for 2016-2030 will be by 1.5–2 times, GDP production growth will reach to 28-36 thousand US dollars per capita in terms of purchasing power versus 17.6 thou USD in 2013. Thus, for a long-term period (until 2050) both the economy of forestry and related social indicators, and the national economy in general should grow by two or more times. This tendency should remain stable in a more distant future.

In conditions of the "green economy" the forestry provides the greatest possible contribution to improving human well-being by producing wood and non-timber products and services and creating "green" jobs [47].

The introduction of the principles of the "green economy" in forestry is associated with sustainable forest management including the increment of natural capital, timber supply to the national economic entities, the development of ecotourism, the reduction of energy consumption, the production development of local fuels, increased sales of minor forest production and secondary forest products.

The basic "green economy" principles for the forest sector of the Republic of Belarus are as follows:

– resource-efficient and sustainable use of forest resources;

– conservation, protection, development and adaptation of forests to climate change and increasing their contribution into greenhouse gases absorption;

– strong social policy and high standard of living due to development of forest sector and forest management;

– enhanced international prestige of the Republic of Belarus as a "green country";

– development of forest ecosystem services.

For each of the principles the national science-based criteria of the "greening" extent of the forest management in the Republic of Belarus have been formulated. Besides, activities for implementing the principles have been developed and used while preparing the National Action Plan for the Implementation of the Principles of the "Green Economy" in the Forestry of the Republic of Belarus until 2030.

The principles of a "green economy" envisage the following directions for the development of forestry:

- Ensuring sustainable production and consumption of "green" ecological products based on certification, labeling, innovation, use of life cycle assessment tools, green building standards, etc.
- Definition and assessment of forest functions, establishment of fees for ecosystem services.

Payment for the forest ecosystem services: moving from theory to practice, in particular, increasing payments for ecosystem services at the national level and developing guidelines and tools that will serve as the basis for paying for ecosystem services and justifying potential financing options.

- Creation of "green" jobs.

Employment and stable wages for the people living in small towns and rural areas. Consideration and discussion of the main threats to the sustainability of the workforce and possible countermeasures at the political level, the development of tripartite (government-trade union-employer) approaches to "green" jobs in forestry using such tools as instructions, minimum standards, increased investment in education and professional training of contractors and forestry workers. Improvement of the system for monitoring of occupational safety and health of forestry workers, ensuring relevant legal compliance as well as rules development taking into account changes in technology and social conditions. Financing of the professional development programs in occupational safety and health for the employers and employees.

• Forest management for sustainable development, including the rural areas.

Promotion of sustainable management of forestry in rural areas (entrepreneurship, capacity building and innovation) by means of regulatory and legal framework enhancement. Introduction of management systems in forestry that would be effective, efficient, less bureaucratic and more transparent. Improvement of interaction between branches of power of various levels and the public.

Improvement of reporting about all aspects of the forest sector and policy building based on objective analysis of good data. Informing, raising awareness, ensuring participation of concerned parties in interdepartmental processes and initiatives related to “green economy” and integrating the module "forests and green economy" into educational programs.

7.6. Implementation Arrangements

Implementation arrangements of the main provisions of the Strategy include the following tools:

– institutional;

– assessment;

– economic.

Institutional tool is formed on the basis of international and national documents that ensure the implementation of the national climate policy as well as the system of special measures and actions including regulatory measures aimed at changing the ideology of forestry development and the assumption of its new values due to the growing climatic role of the Belarusian forests.

It is expedient to make the institutional actions statutory in the State Forest Policy where the ecological (ecological and economic) concept of sustainable development of forestry is considered decisive.

Important tools reinforcing the new institutional environment are the State Forestry Register comprising the information on changes in the carbon budget of forest fund (carbon stocks and flows) and forest monitoring.

Along with the traditional system of observations, forest monitoring includes assessments and forecasts of forest plantations’ conditions and dynamics as well as an information block providing forest management,

in particular, from the viewpoint of climate policy and sustainable forest management.

Assessment tool is determined by the performance indicators of low-carbon forestry development.

The following indicators can characterize the effectiveness of low-carbon forestry:

– absorption efficiency – dynamics of an average annual increment (the greater its value over time, the more efficient the climate-oriented development);

– deposit efficiency – the percentage of annual use of wood stock (the less the percentage, the higher the efficiency);

– anti-efficiency of emission – the ratio of annual growth rate and annual allowable cut (the excess of annual growth over allowable cut indicates the level of anti-efficiency of emission);

– energy efficiency of forest use – the percentage of fuel wood used for energy purposes (evidence of the replacement of non-renewable energy sources by renewable ones).

An integral role in the assessment tool is played by the indicator of the level of carbon-efficient productive forest stock, its amount is affected by the ratio of annual forest stock change to the annual use of forest stock.

Economic tool determines the provisions of rental "green economy" of forestry.

"Green economy" is the economy of improving people's welfare, social justice, reducing environmental risks and sustainable reproduction of natural capital through strengthening the system of state regulation and the formation of values of sustainable development [48, 49, 50, 51].

The economy of forestry is inherently "green".

Based on the content and principles of the rental "green economy", the following trends are the most relevant for the development of the economic tool for forestry:

– natural (ecological) capital of forestry and its ecosystem services;

– natural rent and the procedure for its seizure;

– environmental risks (climate change, biodiversity conservation and the sustainability of forest ecosystems);

– profitability of forestry and the wages of its employees;

– the welfare of rural areas and the interests of local communities.

Without diminishing the importance and relevance of the growth of forestry revenues, the main emphasis in its development should be

implemented on sustainable reproduction of environmental capital, as a determining indicator of its development effectiveness and climate-oriented development.

The state (dynamics) of environmental capital concentrates in itself the balance of economic and environmental interests of the "green economy", its present and future opportunities in meeting diverse human needs. Hence, the problem of its assessment in the system of environmental-economic accounting formed in the country is highly actualized.

It is advisable to create a special insurance fund within the framework of the special insurance system. At the initial stage, the main source of formation of trust insurance fund may be deductions from stumpage value (forest income).

Currently, there is no targeted financing for the environmental climate resources. Large-scale sustainable forest planting and afforestation as well as the system of feasible and focused forest management activities are not normatively declared by the state as a measure to prevent climate change.

Sustainable production of forest ecosystems resulting in the deposition of carbon dioxide and the reduction of the greenhouse effect should be viewed as a global ecological resource. The importance of this resource (in terms of permanent ecosystem service) is determined by international agreements and is ensured by the institutional, legal, and regulatory framework for forestry development including the interests of local communities in the distribution of ecosystem services of their territories.

The absence of an international compensatory financial instrument for depositing carbon dioxide and reducing greenhouse effects hinders the establishment of fees for this service and significantly reduces the effectiveness of sustainable climate-oriented forest management. The main thing here is the financial independence of forestry development. The latter is determined by the rental value of forests and the system of special payments (if any) and (or) tax benefits. The basis of their construction (justification) is environmental (climate) rent. At the heart of its calculation is the alternative cost of environmental resources.

When the international community (interested countries) introduces mechanisms of the international carbon market and a fee-based system of carbon dioxide deposition, the forestry will have a real financial interest in increasing the forests' assimilation potential as a resource

factor to increase their profitability and efficiency (in comparison with traditional kinds of fee-based forest management). In these conditions, it will be possible to observe the growing role of the assessment tool for low-carbon forestry development and its information support using IT technologies.

Because of implementation of this Strategy, the following conditions and mechanisms will be provided:

– ecological and economic conditions for the long-term forestry development of the Republic of Belarus, which regulate the processes of absorption and emission of greenhouse gases based on the superiority of annual growth over the annual forest use (wood use);

– socio-economic conditions of low-carbon forestry development on the basis of further strengthening the legal status of a forestry as an institution with the allocation of self-sufficient entrepreneurial structures, and generally, with an orientation to rental income with a favorable pricing policy in the forest sector;

– mechanisms of climate-oriented development of forestry, among which are:

1. Institutional (forest policy, forest cadastre, forest monitoring).

2. Assessment (a system of indicators of the effectiveness of low-carbon forestry development).

3. Economic – rental “green” economy.

CONCLUSION

1. As a result of the performed work a draft Strategy for Adaptation of Forestry to Climate Change for the period up to 2050 and a draft National Action Plan for Forestry Adaptation to Climate Change up to 2030 have been prepared. The draft documents contain descriptions of the problematic changes related to the ongoing global warming, the current state of the forest fund and the impacts of climate change on its structure, as well as lists of proposed measures to increase forestry adaptation to climate change, indicating the scope of work to be done, the distribution of the proposed activities in stages and indication of responsible executors from the forest fund holders for each activity.

1.1. In Belarus, since 1989, the longest warming period over the entire time of instrumental observations of air temperature during the last 130 years has begun. For the period from 1989 to 2015 the average annual air temperature in Belarus has exceeded the climatic norm adopted by the WMO by more than one degree Celsius. According to the forecasts, it is expected that by 2039 the average annual air temperature will increase in Belarus by another 1°C, the vegetation period will prolong by almost two weeks, and by the end of the century – up to one month. In addition, a significant increase in precipitation during winter and spring seasons, in the heat supply of the growing season, as well as a rise of aridity of the area due to lack of moisture are expected.

Owing to a significant increase in the average annual temperature, the forestry in the southern and eastern regions of the Republic of Belarus is already facing a problem of insufficient soil moisture availability that causes weakening of forest plantations and consequently, large-scale drying-out of stands and exposure to diseases and pests.

1.2. Among the most significant effects of climate change on the forestry in Belarus are the following:

– change in the composition of stands in connection with the change in stability and the shift in the ranges of the main forest-forming species;

– active overgrowing of marshes by woody and shrubby vegetation due to a general decrease in the level of groundwater and an increase in

the intensity of evaporation from the surface of swamps and their water catchment areas;

– the general acceleration of the circulation of substances in forest ecosystems, in particular, the rate of decomposition of tree waste and forest litter;

– enhanced probability of large-scale breeding of forest pests due to a general decrease in the resistance of tree species in combination with improved conditions for reproduction of foliage-eating insects and stem pests;

– increased risk of penetration of invasive pathogens and forest pests;

– impoverishment of flora and fauna of forests in combination with the introduction of forest-steppe and steppe complexes into forest ecosystems;

– enhanced probability of emergence of late-spring frosts due to earlier start of vegetation period and their harmful effect on wood plants;

– a decline in increment of stands under conditions of frequent droughts during the growing season and the lack of moisture at the beginning of vegetation;

– deterioration of wintering conditions for forest plants due to absent or short-term snow cover and thinning of the snow layer;

– change in timing of ripening of foetuses and seeds of woody plants, as well as forest berries caused by earlier start of vegetation period;

– deterioration of accessibility to exploitable marshy forests in winter period due to poor soil freezing;

– an increase in the duration of fire danger period and the number of forest fires that will lead to the release of a significant amount of carbon dioxide, which will exacerbate climate change.

1.3. Within the framework of implementation of the Strategy for Adaptation of Forestry to Climate Change for the period up to 2050, the following indicators will be achieved:

– forest cover of the territory will grow up to 42.0%;

– the share of mixed plantations will increase up to 77%;

– the share of hardwood stands will increase up to 6.5%;

– the share of natural regeneration in the total volume of forest restoration will increase up to 50% due to an increase in the share of cuttings with preservation of undergrowth and non-clear cuttings up to the level of 7 and 35% respectively;

– the share of combined regeneration of forests will reach 20% which will allow to make greater use of the forest potential for natural regeneration;

– as a result of production of seeds of the selected category the share of seed farming based on the 'population' seed management will reach 20%;

– the number of used tree species will reach 12 due to the involvement of such species as European beech and White fir into the silvicultural production;

– in the clonal archives, all plus and superior trees will be preserved;

– the area of genetic reserves will increase up to 1.5%;

– sustainable populations and trees of Scots pine and European spruce will be identified, that will become the basis for the restoration of forests in the area of negative impacts of climate change processes;

– coverage of the early forest fire detection system based on remote methods will reach 95%;

– in order to increase the availability of sites for forest management activities, including forest safety and protection, at least 100 km of forest roads will be built annually;

– the area of forest pathological surveys of the forest fund, including the remote sensing methods, will increase twice (up to 3 mln ha per year);

– the area of expedition-based forest-pathological surveys will increase up to 100 thou ha per year;

– the area covered by forest protection measures with the use environmentally safe biological methods will increase twice up to 120 thou ha per year;

2. National Action Plan on Increasing the Absorption of Greenhouse Gases by Sinks (Forests, Swamps) until 2030 has been drafted. The National Action Plan on Increasing the Absorption of Greenhouse Gases by Sinks (Forests, Swamps) until 2030 is an implementation mechanism of the United Nations Strategic Plan for Forests for 2017–2030 (UNSPF) with regard to the global forest goal 1.2 "The world's forest carbon stocks are maintained or enhanced" and a contribution of the forest sector of the Republic of Belarus to Sustainable Development Goals (SDG) as a member country of Sustainable Forest Management (SFM). This National Plan is a contribution of the forest sector into the implementation of Presidential Decree of the Republic of Belarus

No.345 dated 20.09.2016 by which Belarus committed to the Paris Agreement with pledge to reduce greenhouse gases emissions.

The National Plan specifies forestry actions within the State Program of Measures on Climate Change Mitigation for 2013–2020 approved by the Resolution of the Council of Ministers of the Republic of Belarus No.510 dated 21.06.2013. The National Action Plan covers the review and intended actions and measures to be taken by the forest sector. The Action Plan contains the following chapters: general provisions; forests of Belarus as a source of carbon dioxide absorption; estimation of the level of the carbon dioxide absorption by Belarusian forests until 2030; strategy for increasing the level of the carbon dioxide absorption by Belarusian forests; measures of the National Action Plan on increasing the carbon dioxide absorption. Mandatory provisions of the National Action Plans include institutional environment; scope of work to increase the level of the carbon dioxide absorption; expected outcomes on increasing the annual carbon dioxide absorption resulting from implementation of the National Action Plan developed within this task.

2.1. Over the period from 1956 to 2017 the forests of Belarus have captured about 2 111 million t of atmospheric carbon with subsequent sequestration in phytomass and soils of the forest fund. This amount can be compared to the "stock" (absorption) of nearly 7 740 million t CO_2. Over the same period the increment of CO_2 ("emission") in the earth atmosphere amounted to approximately 420 billion t, so the sustainability of carbon sequestration capacity of Belarusian forests deserves high appreciation. Carbon balance of the forest fund is not time-stable due to the dynamics of wood stock and the level of forest utilization. Carbon budget can be altered by the following factors: reduced areas of forested lands, changing age structure of forests due to increasing areas of mature and ripening stands, increased wood harvest by final fellings, regeneration cuts, conversion and other cuts. These factors are also able to redirect the net flow of carbon into the atmosphere. Carbon flow monitoring and mechanism of their calculation are important tasks of the forest sector. Predominating "emission" in the carbon balance of the Belarusian forest ecosystem can adversely affect the national forest sector under the conditions of globally rising pressure in the field of carbon dioxide emission into the atmosphere. Sustainable and dynamic development of forestry in the Republic of Belarus creates good conditions for maintaining the same dynamics of forest fund both in the short-term (until 2030) and long-term (until

2050) prospects. Whereas the total area of the forest fund will remain unchanged (9 565.8 thousand ha), the forested lands are predicted to increase until 2030 (+80.6 thousand ha) with the total wood increment of 47.4 million m^3. Steady wood harvest volumes can ensure stabilized carbon budget in the forests of Belarus.

Wood harvest is estimated to increase by average 1694 thousand m^3 until 2030 as compared to 2017. Consequently the level of annual carbon dioxide absorption is expected to decrease by average 1708 thousand t annually. Estimated carbon removal from the forest fund of the Republic of Belarus due to wood harvest will amount to 6523 thousand tC for 2018–2030 that is equal to carbon dioxide "emission" of 23912 thousand t CO_2 due to wood harvest, including 7874 thousand t CO_2 for 2018–2025 and 16038 thousand t CO_2 for 2026–2030. The declining tendency of carbon stock contradicts the national policy in the field of climate change mitigation. The forest sector must compensate the CO_2 emissions from wood harvest by means of measures to increase the carbon sequestration capacity of forests. In this way, the present level of the carbon dioxide absorption will be maintained. Responsible forest management and efficient actions that can affect carbon flows can increase the level of carbon dioxide absorption by the forest fund of Belarus.

2.2. Strategic goals of the forest sector aimed at enhancing its role in the climate change management in the XXI century by means of carbon dioxide absorption by the forest fund should include the following actions and measures.

Measures to improve the institutional framework of forest sector actions on increasing the carbon dioxide absorption include: development of the sectoral program for increasing of average density of forests; entry of the following data into the Forest Cadastre: total carbon amount of the forest fund, phytomass carbon of the forest fund, total dynamics of carbon sequestration by the forest fund; entry of the following provision into the "Regulations of determination and approval of allowable final cuts in the forests of the Republic of Belarus": carbon weight sequestered by wood of the established allowable cut volume shall not exceed annual carbon absorption achieved by the planned target actions on increasing the carbon sequestration capacity of forests and non-forest lands of the forest fund; Supplementing forest management plans with the section "Measures on increasing the level of carbon dioxide absorption by forest fund"; Development of TCCP "Rules of calculation of greenhouse gases absorption and emission by

forest fund components"; Development of databank "Swampy forests of transition and raised types that are exploitable, unsuitable for logging, used for carbon sequestration"; Entry of the following provision into the Rules of Forest Fellings of the Republic of Belarus: final cuts are not allowed in swampy forests of transition and raised types used for carbon sequestration and biodiversity conservation.

Forest sector measures to increase carbon dioxide absorption include: change of forest management regime in swampy forests of transition and raised types into nature protection regime – 10%; creation of forest plantation by root-balled rooted nursery stock – 2.8%; non-clear commercial cuts – 3.2 %; restoration of low-grade forest stands – 2.5%; energy uses of wood harvested from debris-strewn forest – 20%; energy uses of logging residues from final and other felling sites – 23%; support for natural regeneration in ripening and mature forests – 2.5%; increase in average density of stands as compared to 2017 +0.016 (2025) and +0.044 (2030) – 30%; long-term withdrawal of certain forest areas from forest management – 9.2%.

Estimated level of carbon dioxide absorption by the forest fund of the Republic of Belarus amounts to 47012.9 thousand t CO_2/year for 2025 and 47249.0 thousand t CO_2/year for 2030. These figures exceed the corresponding level of 2017 by 0.06% and 0.56% respectively. The achievement of these estimated figures is a relevant goal of the forest sector of the Republic of Belarus. This will lead to the achievement of the goal of the National Action Plan, i.e., maintenance of the achieved level of annual carbon dioxide absorption by the forest fund under the conditions of increased (41.4%) annual wood harvest by final felling, regeneration cuttings, conversion and other fellings until 2030.

3. The review of concepts and principles of a "green economy" in foreign countries and the Republic of Belarus has made it possible to justify and define main "green economy" principles for the forest sector of the Republic of Belarus:

– resource-efficient and sustainable use of forest resources;

– conservation, protection, development and adaptation of forests to climate change and promotion of their greenhouse gases absorption capacity;

– strong social policy and high standard of living due to forestry development and forest use;

– enhanced international prestige of the Republic of Belarus as a "green country";

– development of forest ecosystem services.

For each of the above principles the scientifically-based national criteria have been developed in order to determine how "green" the forest management in the Republic of Belarus is, together with relevant actions to be taken. Both the criteria and the action have been incorporated into the National Action Plan for the Implementation of the Principles of the "Green Economy" in the Forestry of the Republic of Belarus until 2030.

3.1. The draft National Action Plan for the Implementation of the Principles of the "Green Economy" in the Forestry of the Republic of Belarus until 2030 contains 23 actions to be taken. The following actions are worth mentioning:

– modernization of the forestry and logging production, increasing of their efficiency and competitiveness; creation of conditions for service market development (use of multi-operation machines (harvesters) for felling operations when harvesting felling-area resources, regular workshops on efficient cutting methods and forest regeneration);

– manufacturing of high added-value products;

– use of low-quality firewood and logging residues for energy purposes;

– rational utilization of non-timber resources;

– forest road construction;

– support for natural regeneration in mature forests;

– restoration of low-grade forest stands;

– withdrawal of certain forest areas from forest management;

– increasing the forest fund areas under forest pathology research, including remote sensing;

– development of information support system of the environmental risks assessment in the forest sector through creating a databank of forest mortality cases due to various factors across forestry enterprises;

– development and approval of a methodology "Procedure for economic assessment of environmental hazards in the forest sector";

– promotion and support to the national forest science and education;

– allocation of forest stands with good ecotourism capacity, their integration into ecological routes and trails;

– marketing and promotion of tourist services rendered by forestry enterprises, creation of additional workplaces in the "green economy" sector, etc.

The National Action Plan contains description of volumes, deadlines (divided into two stages: 2018–2025 and 2026–2030), responsible executors, estimated efficiency and expected outcomes of each action.

3.2. The National Action Plan for the Implementation of the Principles of the "Green Economy" in the Forestry of the Republic of Belarus until 2030 is intended to achieve the following performance indicators:

– timber volume by harvesters during clear cutting will amount to 75% of the total cutting volume by 2025 and 80% – by 2030;

– energy uses of low-quality firewood will amount to 53471 thousand m^3 for 2018–2025, to 34845 thousand m^3 for 2026–2030;

– energy uses of logging waste from final and other cuttings will enhance;

– annually about 100 km of forest roads is expected to be constructed;

– assisted forest regeneration in mature stands will cover 27840 ha for 2018–2025, 26740 ha for 2026–2030;

– average density of stands will increase by 0.016 by 2025 and by 0.044 by 2030 as compared to the year 2017;

– change of forest management regime in swampy forests into conservation regime will take place on 220.0 thousand ha for 2018–2025, 238.6 thousand ha for 2026–2030;

– forest areas monitored by remote early fire detection systems will increase and amount to 40% of the total forest fund area by 2025 and 50% by 2030;

– forest pathology research, including remote sensing, will be carried out on minimum 1500 thousand ha by 2025, minimum 2000 thousand ha by 2030;

– marketing, promotion and development of tourism services rendered by forestry enterprises will create additional "green" jobs.

4. In recent years, purposeful and productive work has been conducted in Belarus with involvement of large financial resources into the forest economy transformation. According to the Government's estimates, the national forest sector is characterized by the accelerated rates of development and significant structural changes towards industries with advanced wood processing.

The high-technology economy of the forest complex which is currently being formed and which is indicated by market prices for wood raw materials, will ensure the current transformation processes and improve its financial condition. This circumstance does not exclude the target budget financing of forestry activities. Until the breakeven wood industry gets real, which ensures coverage of the forestry's costs

by own (forestry's) incomes, it is not justified to cancel state financing of forestry activities (forest enterprises).

4.1. According to the forecast estimates, the volume of sales of forest products will increase in the future (by 2030) by almost 3.5 times compared to 2013, the wages will rise by 2.7 times, while the increment of forest capital will be about 20% and the ecosystem services will increase by 1.3 times. This tendency expressed in constant prices indicates the absolute increment of natural capital and ecosystem services meeting the conditions for a strong sustainability of development supported by economic growth and the achievement of social goals.

According to the National Strategy for Sustainable Development until 2030, (NSSD-2030), over the period 2016-2030 the GDP will grow 1.5–2 times and the GDP production growth will reach 28–36 thousand US dollars per capita in terms of purchasing power versus 17.6 thou of 2013. Thus, for a long-term period (until 2030) both the forestry economy with the related social indicators, and the national economy as a whole must grow two or more times. This tendency should remain stable in a more distant future.

4.2. The principles of a "green economy" envisage the following directions for the development of forestry:

- Ensuring sustainable production and consumption of "green" ecological products.

Based on certification, labeling, innovation, use of life cycle assessment tools, green building standards, etc.

- Definition and assessment of forest functions, establishment of fees for ecosystem services.

Payment for the forest ecosystem services: moving from theory to practice, in particular, increasing payments for ecosystem services at the national level and developing guidelines and tools that will serve as the basis for paying for ecosystem services and justifying potential financing options.

- Creation of "green" jobs.

Employment and stable wages for the people living in small towns and rural areas. Consideration and discussion of the main threats to the sustainability of the workforce and possible countermeasures at the political level, the development of tripartite (government-trade union-employer) approaches to "green" jobs in forestry using such tools as instructions, minimum standards, increased investment in education and professional training of contractors and forestry workers. Improvement

of the system for monitoring of occupational safety and health of forestry workers, ensuring relevant legal compliance as well as rules development taking into account changes in technology and social conditions. Financing of the professional development programs in occupational safety and health for the employers and employees.

• Forest management for sustainable development, including the rural areas.

Promotion of sustainable management of forestry in rural areas (entrepreneurship, capacity building and innovation) by means of regulatory and legal framework enhancement. Introduction of management systems in forestry that would be effective, efficient, less bureaucratic and more transparent. Improvement of interaction between branches of power of various levels and the public. Improvement of reporting about all aspects of the forest sector and policy building based on objective analysis of good data. Informing, raising awareness, ensuring participation of concerned parties in interdepartmental processes and initiatives related to "green economy" and integrating the module "forests and green economy" into educational programs.

4.3. As a result of implementation of the activities of the climate-oriented Strategy for development of forestry the following results will be achieved:

– stability and productivity of forest stands will increase;

– at least 69 hectares of provenance trial plantations of indigenous and promising introduced species will be created, which will allow to monitor the condition of forest plantations of various geographic origin in a changing climate;

– the final felling area will increase with preservation of the undergrowth up to 7%;

– the area of non-clear commercial cuts will increase up to 35 % of the total cutting volume;

– by 2030 improvement fellings will be aimed at formation of only mixed stands;

– the share of combined regeneration of forests will increase up to 20% of the total scope of reforestation activities which will allow to make greater use of the forest potential for natural regeneration;

– creation of coniferous forest plantations from selective planting material will reach 100% while maintaining a 1:1 ratio of population and plantation seed production, at the same time the role of population seed farming will increase for obtaining genetically improved seeds;

– the share of forest stands with the predominant hardwood species will increase up to 6.5% of the forest fund area;

– the share of mixed forest plantations will reach 100% of the total volume of sowing and planting amount by 2020;

– the number of tree species used for reforestation and afforestation will increase at least by two species;

– the volume of reforestation, including combined reforestation, using container seedlings grown from selection seeds will reach 30% of the total volume by 2020, which will allow to purposefully influence the stability and productivity of future plantations;

– the area of genetic reserves, created on the basis of the most valuable natural stands, will reach 1.5% of the total area of the forest fund;

– the clonal archives will embrace at least 60% of the allocated plus trees and 100% of superior trees;

– activities on identification and use of local populations in forest seed production that are resistant to the negative effects of climate change will be conducted on the entire territory of the forest fund;

– the area of plantations of population selection will reach 460 ha, which will allow to use actively the genetic resources of the most valuable local populations;

– 100% of plus trees will be involved in the work on testing hereditary qualities in order to allocate elite trees;

– coverage of the early forest fire detection system based on remote methods will reach 100% of the forest fund area;

– at least 3 300 km of forest roads, increasing the availability of forest fund sites in extreme weather conditions and forest fires will be built;

– the area of pathological surveys of the forest fund, including the remote sensing methods, will embrace at least 300 thou ha per year);

– the area of expedition-based forest-pathological surveys will increase up to 10 thou ha per year;

– forest protection measures using environmentally safe biological methods will be carried out on an area of at least 12 thou ha per year;

– forest cover of the territory will grow up to 42.0%.

4.4. As a result of implementation of the Long-term Forestry Development Strategy of the Republic of Belarus with low greenhouse gas emissions for the period up to 2050, the following results will be provided:

– ecological conditions for the long-term forestry development of the Republic of Belarus, which regulate the processes of absorption and emission of greenhouse gases based on the superiority of annual growth over the annual forest use (wood use);

– socio-economic conditions of low-carbon forestry development on the basis of further strengthening the legal status of a forestry as an institution with the allocation of self-sufficient entrepreneurial structures, and generally, with an orientation to rental income with a favorable pricing policy in the forest sector and efficient organizing of trading at exchange auctions;

– mechanisms of climate-oriented development of forestry, among which are:

1. Institutional (forest policy, forest cadastre, forest monitoring).

2. Assessment (a system of indicators of the effectiveness of low-carbon forestry development).

3. Economic – rental “green” economy.

IMPLEMENTATION OF THE FORESTRY DEVELOPMENT STRATEGY, CHALLENGES AND RISKS WHILE ACHIEVING OBJECTIVES

The expected outputs of the Strategy and the National plans can only be delivered in coordination with the concerned state run public authorities within achievement of the projected sustainable development indicators. Possible extreme nature or anthropogenic impacts on the forest ecosystem in Belarus can impede the attainment of the objectives and require additional measures on eliminating or minimizing these impacts.

Implementation of the developed activities is facing objective risks connected with insufficient funding, primarily from extrabudgetary sources.

A number of activities can be realized in necessary scope and in the established terms only with financial support from international funds, private investments and other extrabudgetary sources.

ANNEX 1

Summary of Terms of Reference within Activity 3.1.4

The Scientific consultancy services are delivered within the framework of the Belarus Forestry Development Project (the international technical assistance project), registered by the Ministry of Economy of the Republic of Belarus (March 3, 2015, No.2/15/000747), under Contract No. BFDP/GEF/CQS/16/25-26/17, concluded between the Ministry of Forestry of the Republic of Belarus (hereinafter the Ministry of Forestry), BSTU and Export and Production Republican Unitary Enterprise "Bellesexport" (hereinafter UE "Bellesexport").

The subject matter of the consultancy services delivered by BSTU is implementing Activity 3.1.4: "Consultancy Services to Develop Strategies and Actions Plans for the Adaptation of the Belarusian Forestry Sector to Climate Change and to Implement the Principles of "Green Economy".

The objective of the assignment within Activity 3.1.4 stipulated by the Terms of Reference is formulated as follows:

Update and Develop Strategies and Actions Plans for the Adaptation of the Belarusian Forestry Sector to Climate Change and to Implement the Principles of "Green Economy". These strategies and plans shall be scientifically based and include international experience.

The following strategies and plans shall be prepared:

– Strategy for the Adaptation of the Belarusian Forest Sector to Climate Change until 2050 (updating);

– National Action Plan for Forestry Adaptation to Climate Change until 2030;

– National Action Plan on Increasing the Absorption of Greenhouse Gases by Sinks (Forests, Swamps) until 2030;

– National Action Plan for the Implementation of the Principles of the "Green Economy" in the Forestry of the Republic of Belarus until 2030;

– Long-Term Forestry Development Strategy of the Republic of Belarus with Low Greenhouse Gas Emissions until 2050.

Selection of an organization for the assignment was performed by assessing the qualification requirements: experience and competency of the personnel, availability of the scientific research in the field of Activity 3.1.4 and its adoption in the forestry practice.

The score system has been used for the evaluation of proposals:

1. Experience in developing scientific and technical projects for the forestry sector of the Republic of Belarus (minimum 3 years): 10 points;

2. Availability of scientific research:

2.1. in the field of optimization of species structure and age-class composition of the forest fund – 20 points*;

2.2. in the field of adaptation of the forestry to climate change – 20 points*;

2.3. in the field of the "green economy" – 20 points*.

3. Availability of the basis of permanent scientific and practical objects for the issues of the Assignment** – 20 points;

4. Managerial abilities, knowledge of English, confirmed by the appropriate Certificate – 10 points;

Total: 100 points

The best qualified and experienced organization was selected to the negotiations.

Belarusian State Technological University was recognized the winner in the competition.

* If the organization is the main executor of researches and developments, then it is assigned the highest score of 20 points for it.

** If the organization possesses permanent scientific and practical objects for with a lifespan of 20 years or more, it is assigned the highest score of 20 points for it.

ANNEX 2

Belarusian State Technological University as a Consultant for delivery of services within Activity 3.1.4.

Belarusian State Technological University (BSTU) is a leading higher educational establishment of the Republic of Belarus and the CIS in the forest, chemical and printing production sectors.

In June, 2009, BSTU was the first among the higher educational institutions of Belarus to certify its quality management system (QMS) in the national conformity assessment system. In December, 2009, BSTU was also the first among the higher institutions to certify its QMS in the German accreditation system DGA; by doing this it opened the way for the other institutions to obtain two certificates simultaneously.

The University has introduced a quality management system and is certified for conformity to STB ISO 9001-2015 in the national conformity system of the Republic of Belarus and for conformity to DIN EN ISO 9001-2015 in the German accreditation system DAKKS.

In 2011 BSTU was given the Belarus Government Quality Excellence Award.

Based on the results of 2013-2015 BSTU is recognized as the best university in the category "Strong performance in training of highly qualified scientific workers".

In 2016 BSTU successfully passed the reaccreditation as a scientific organization at the State Committee on Science and Technology of the Republic of Belarus and the National Academy of Sciences of Belarus.

By Resolution of the CIS Council of Heads of Governments dated November 22, 2007, **the educational institution "Belarusian State Technological University" (BSTU)** was granted the status of **the Basic organization for education in the field of forestry and forest industry of the CIS member states** (hereinafter the Basic organization).

The Basic organization was created for the purpose of organizational, teaching and methodical improvement of training of specialists with higher education in the field of forestry and forest industry of the CIS member states. In this process due regard is given to the tasks of

forming and developing a single (common) educational space of the Commonwealth of Independent States.

In its operations the Basic organization is guided by the CIS Charter, decisions of the CIS Council of Heads of States and the Council of Heads of Governments, international agreements in the field of education concluded within the CIS.

The Basic organization carries out its activities in cooperation with the Council for Cooperation in Education of the CIS Member States (hereinafter referred to as the Council), the central educational authorities of the CIS member states, the CIS Executive Committee and informs the Council about its activities.

The areas of focus of the University as the Basic organization are as follows:

– development of recommendations for determining the optimal structure and content of higher education for training of specialists for the CIS member states in the field of forestry and forest industry;

– analysis and development of recommendations for improvement of educational standards, curricula and programs, preparation of textbooks, teaching aids and other educational and methodical literature for higher educational institutions of the CIS member states;

– participation in postgraduate training, advanced training and retraining of specialists of the CIS member states in forestry and forest industry;

– development of new methods and technologies for training and retraining of specialists in the field of forestry and forest industry;

– organizing and conducting scientific research on topical issues of education in the field of forestry and forest industry;

– assistance in enhancing cooperation of higher educational institutions and research organizations of the CIS member states in the field of forestry and forest industry;

– providing scientific and methodological support for training of highly qualified specialists for the forestry and forest industry.

BSTU is also a member of the International Center of Forestry and Forest Industry (**ICFFI**). The Center was founded in 1995 on the basis of Saint Petersburg State Forest Technical University. The goal of ICFFI is cooperation with foreign educational and scientific organizations in the area of education, scientific research and business.

For special achievements in social and cultural development, multi-year efficient work in preparing highly qualified personnel in

2010 BSTU was awarded the Honorary State Flag of the Republic of Belarus. In 2011, the University was awarded the Prize of the Government of the Republic of Belarus for Quality Achievements in Introduction of Highly Efficient Methods of Quality Management and the Provision of Competitive Services. In the same year, BSTU was accredited as a scientific organization and became a member of the Belarusian-Kazakhstan scientific and educational consortium.

By instruction of the Government, a vertically integrated educational research and production complex was established at BSTU, which contains 48 departments and more than 25 of their branches at leading enterprises of the country, 5 colleges (Polotsk State Forestry College, Vitebsk State Technological College, Gomel State Polytechnic College, Bobruisk State Forest Engineering College, Belarusian State College of Building Materials Industry) and 2 educational and experimental forest enterprises.

48 structural scientific departments have been created at the University, including 12 applied and joint research laboratories. The scientists of the University are actively involved in fulfillment of more than 580 projects within 35 scientific and technical programs of different levels. More than 400 enterprises and organizations of the republic cooperate with the technological university within business contracts aimed at solution of applied problems.

A breakthrough of high-technology products and research and development accomplishments to the world markets can be achieved only with the availability of modern high-technology equipment. Therefore, the departments of the University, as well as the Center for Physical and Chemical Investigation Methods, specially established as a joint-use center with the unique equipment, are equipped with modern scientific instruments, equipment and machines from the leading foreign manufacturers. This allows conducting research at a high level and preparing engineering personnel on the basis of a proactive approach.

Currently, the University consists of: the Institute for Advanced Studies and Retraining, 8 faculties, 48 departments, a BSTU branch “Negoreloe Forest Experimental Enterprise” with a decorative plants nursery, a botanical garden and training and production wood processing facilities, 2 educational and methodological associations of universities and 5 branches for training specialists with secondary professional and vocational technical education.

The total number of employees at the University is 1325. Educational and methodical work is provided by 563 teachers. On an ongoing basis, the educational process is carried out by 1 academician and 2 corresponding members of the National Academy of Sciences of Belarus, 48 doctors of science and 397 PhDs. Teachers under the age of 35 make up about 22% of the total amount of PhDs. The source of recruitment of pedagogical staff on a permanent basis is mainly the graduate school and the research division of BSTU. The University employees defend up to 25 PhD and 1–2 doctoral thesis annually. Over the past 5 years 109 PhD and doctoral thesis have been defended.

The University is equipped with above 1,470 personal computers. Electronic versions of textbooks and teaching aids, texts of lectures, laboratory and practical classes have been developed. The cumulative number of print and electronic resources used to support the educational process and scientific research totals to about 1.3 million copies. Besides, a new automated information and library system "MARC-SQL" is functioning.

The University acts as the principal implementing partner of the State Scientific and Technical Program "Forests of Belarus - sustainable management, innovative development, resources". This includes the following programs:

- To develop and introduce resource-saving technologies and equipment that provide expanded reproduction and rational use of wood resources in the Byelorussian SSR for 1991–1995 and for the period up to 2005 (33.01 RC);
- To develop and introduce systems of intensive forest management, resource-saving equipment and technologies that ensure the fulfillment of ecological and economic functions by forests, reducing consequences of the accident at the Chernobyl Nuclear Power Plant and rational use of forest resources (State Scientific and Technical Program "Forest – Ecology and Resources", 1997–1998);
- To develop and introduce new equipment and technologies in forestry, logging and processing industries, ensuring increased forest productivity, rational use of forest resources, energy saving, production of competitive and import-substituting materials (State Scientific and Technical Program "Forests of Belarus and their rational use", 1999–2000) ;
- To improve and introduce new technologies in forestry and industrial production, ensuring increased productivity and sustainability

of forests, rational use of forest resources, production of competitive and import-substituting products, strengthening economic, ecological and social functions of forests (State Scientific and Technical Program "Forests of Belarus", 2001–2002);

- the State Scientific and Technical Program "Forests of Belarus", 2003–2005 (with the same name as the previous one);

- Development and adoption into the production process of new methods, machines and technologies for multi-purpose forest use and sustainable forest management, ensuring their security, protection and reproduction, enhancing the efficiency of the forest sector of the republic, improving timber processing, increasing budget revenues from the sale of forest products (State Scientific and Technical Program "Forest Management and Rational Forest Use", 2006–2010);

- Development and adoption into the production process of new methods, means and technologies for reproduction, security and protection of forests, sustainable forest management and multi-purpose forest harvesting, ensuring an increase in forest productivity and sustainability, enhancing their resource, social and economic and environmental role, rational multi-purpose use of forest resources, enhancing efficiency of the work of the forest sector of the republic (State Scientific and Technical Program "Forests of Belarus - Productivity, Sustainability, Efficient Utilization", 2011–2015);

- Development and introduction into forestry and industrial production of new methods, means and technologies of creating new forests, their cultivation, security and protection, sustainable management, efficient use of forest resources, which ensure increase in forest productivity, strengthening their social and economic and environmental role, rational multi-purpose forest harvesting, enhancing the efficiency of the forest sector of the republic (State Scientific and Technical Program "Forests of Belarus - Sustainable Management, Innovative Development, Resources", 2016–2018).

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General editorship, Executive Summary, Chapters 1 and 2, Conclusion – I.V.Voitov and V.G.Shatravko; Chapter 1, Conclusion – N.N. Yurevich; Chapter 6, p. 2.3 – A.V. Lednitski; Chapter 7, p. 2.4 – A.V. Neverov; Chapters 3 and 4, p. 2.1 – V.V. Nosnikov; Executive Summery, Chapter 5, p. 2.2 – L.N. Rozhkov.

Scientific publication

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ECOLOGICALLY ORIENTED FORESTRY DEVELOPMENT IN BELARUS IN THE CONTEXT OF CLIMATE CHANGE

Author's edition

Translated by *O. Stepaniuk*

Computer-aided makeup *O. Shantarovich*

Manuscript approved for print 14.08.2018. Format 60×84 1/16.
Offset paper. Risography printing.
10.6 standard printed sheets. 10.9 published sheets.
Number of copies 200. Order .

Publishing and printing:
EI "Belarusian State Technological University".
Certificate of national registration of publisher,
manufacturer and distributor of print publications
No. 1/227 from 20.03.2014.
13a, Sverdlova str., 220006, Minsk.