Climate change and adaptation practices in the forestry sector of the Russian Federation

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Abstract. Over the past 10 years, the country's legal and regulatory framework has been developing instruments related to sustainable development and security in the context of climate change. To investigate the practice of planning measures for adaptation of the Russian forestry sector to climate change, an analysis has been made of the information on planned measures for the conservation of the ecological potential of forests, adaptation to climate change and increasing forest resilience provided in the forest planning documents of the constituent entities of the Russian Federation. The information in the Forest Plans shall be correlated with the results of the vulnerability and risk assessment carried out for the specific forestry conditions and forms an appropriate set of adaptation measures. The conducted study showed that 100% of the constituent entities whose forest plans contain adaptation indicators have planned to carry out adaptation measures to the risk associated with the increased frequency of wildfires. The analysis showed no correlation between the amount of work and the cost of implementing each of the planned adaptation actions and events. At the same time, the validity of risk adaptation priorities in some constituent entities probably requires further refinement and clarification.

1. Introduction

The past three decades have been marked by intensive scientific research into the potential impacts of climate change-related effects on different kinds of natural and social systems. The research findings have supported the formulation and implementation of policies aimed at reducing the adverse effects of climate change [1-3].

Accumulated global experience shows that it is advisable to plan and implement preventive measures to protect people, the economy and the state from the negative effects of climate change [4, 5].

The sensitivity of vast Russian forests to warming could have significant consequences for the climate system in terms of water, carbon and energy exchange between the biosphere and the atmosphere. This makes Russia's forests a key factor in global climate regulation, with the future climate of the planet largely dependent on Russian land use policies and forestry practices.

Since 2008, the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) has published the Climate Change Impact Assessment Reports for the Russian Federation [6], which provide an assessment of the impact of observed and expected climate change on the country's territories. The first report noted that there has been an increase in the frequency of wildfires since 1985, due, among other things, to climate change [6]. The second and subsequent assessment reports included a separate section on the role and extent of climate change impacts on...
Russian forestry [6]. In 2017, the Roshydromet has prepared a ‘Report on Climate Risks in the Russian Federation’, in which it reflected the possible adverse effects of climate change on forestry in the Russian Federation. These include an increase in forest fires, outbreaks of insect pests, increased frequency of extreme weather events and changes in species diversity [7].

The results of Russian scientific research on the extent to which observed and projected climate change affects the functioning of natural and socio-economic systems have provided a solid foundation for the implementation of national climate policy. In 2009, the Climate Doctrine of the Russian Federation (hereafter referred to as the Climate Doctrine), which is a system of views on the objectives, principles, content and ways of implementing a unified national policy on climate change, has been approved by a presidential decree. A year later, an Integrated Research Plan for Weather and Climate by 2020 has been compiled.

Over the past decade, the Climate Doctrine has been an important and successful reference point for both domestic and foreign climate policy in the Russian Federation. In accordance with its underlying principles, government documents reflecting the basic provisions of the country's climate policy and measures for their practical implementation are being developed.

The strategic objective of the policy of the Russian Federation, implemented, among others, by the Federal Forestry Agency, is to ensure safe and sustainable development of the forestry sector of the economy.

The content of Russia's forest management policy is determined by the tasks that are subordinate to the achievement of its strategic goal and are addressed with due consideration of the specific features of the Russian Federation in the context of climate change, as reflected in the provisions of the Climate Doctrine of the Russian Federation and the activities of the Integrated Implementation Plan.

Key issues on the conservation of the ecological potential of forests, adaptation to climate change and increasing forest resilience, as well as those aimed at reducing anthropogenic impacts on the climate system are addressed in a number of regulatory and legal documents of the Russian Federation at various levels, including those of the Federal Forestry Agency.

The development and implementation of measures for the use of forests to reduce climate change, as well as the adaptation of the forestry sector of the economy to these changes while solving the problem of preserving the ecological potential of forests is stipulated by subparagraph ‘V’ of paragraph 18 of the Basic State Policy in the Use, Preservation, Protection and Reforestation of Forests in the Russian Federation until 2030, approved by Order N 1724-r of the Government of the Russian Federation of September 26, 2013.

The Decree N 1989-r of the Government of the Russian Federation, dated 20.09.2018 has approved the Strategy for the Development of the Forestry Sector of the Russian Federation until 2030. This strategy recognises that the challenges of forest conservation and use are becoming increasingly diverse and complex. Forest management standards have been changing to meet increased international, social, environmental and economic requirements. Threats to forests from fires, pests and other adverse factors are now increasing, exacerbated by the effects of climate change.

In accordance with the provisions of Article 1 of the Forest Code of the Russian Federation, the conservation of the habitat-forming, water-protective, protective, sanitary-hygienic, health-improving and other beneficial functions of forests in the interests of ensuring the right of everyone to a healthy environment, as well as the use of forests with consideration for their global ecological significance are the basic principles of the forest legislation of the Russian Federation.

In addition, climate change aspects that take into account the need to reduce anthropogenic impacts on climate as well as adaptation to climate change have considered a number of normative legal documents of the Russian Federation at different levels.

In 2017, the Federal Forestry Agency has approved a Long-Term Climate Change Adaptation Plan and implementation of a set of measures to improve the regulation of greenhouse gas emissions in forestry. This plan aims to implement activities to reduce greenhouse gas emissions from deforestation and forest degradation, strengthen conservation, sustainable management and increase carbon storage
in Russian forests. The above-mentioned measures have been published currently in regional planning documents.

For the purpose of practical implementation of the state forest policy, the Ministry of Natural Resources and Environment of Russia issued the Order N 692 of December 20, 2017 ‘On Approval of the Model Form and Composition of the Forest Plan of the Subject of the Russian Federation, the Procedure for its Preparation and Amendment’. This document entered into force on April 20, 2018. The forest plan of a constituent entity of the Russian Federation is a ten-year forest planning document. In accordance with the aforementioned Order, the newly approved Forest Plan template reflects, for the first time, activities to reduce greenhouse gas emissions from deforestation and forest degradation, enhance conservation, sustainable management and forest carbon stocks, vulnerability and adaptation measures taken to respond to climate change at the constituent entities' level of the Russian Federation.

2. Methods

The purpose of this study is to analyse the planning and implementation of adaptation measures for the forest sector of the Russian Federation's economy over the past decade.

The analysis of objectives and approaches to forestry adaptation to climate change, and the interpretation of the data were based on the provisions reflected in a number of legal and regulatory documents of the Russian Federation at various levels, including those of the Russian Federal Forestry Agency. In order to study the state of practice of planning and implementation of measures for adaptation of the forest sector of the economy of the Russian Federation to climate change, an analysis of planned forestry measures reflected in the Forest Plans of the constituent entities of the Russian Federation has been carried out.

Anthropogenic climate change is associated with significant risks for society and nature. The two fundamental options for society's response to reduce these risks are climate change reduction and adaptation to climate change. As for climate change, the reduction means limiting global climate change by reducing greenhouse gas emissions or increasing their sinks. An adaptation refers to actions directed at a vulnerable system in response to actual or anticipated risks in order to reduce harm from climate change. In general, reduction and adaptation are complementary rather than mutually exclusive alternatives.

Regulatory legal documents of the Russian Federation contributing to the implementation of measures aimed at achieving forest sector adaptation to climate change have a strict hierarchy, ranging from the federal to the regional level, as well as documents within individual organisations (sectoral, departmental and corporate innovation and technology programmes). The Climate Doctrine of the Russian Federation is the founding normative document, but it does not contain indicators for adaptation to climate change impacts.

As indicated above, the development of measures to preserve the ecological potential of forest ecosystems, adapt to climate change and increase forest resilience is stipulated in the standard form of the forest plan of a constituent entity of the Russian Federation, but the document does not provide a mechanism for monitoring the implementation of adaptation measures.

Forest management regulations and forest development projects, which are documents hierarchically subordinate to the forest plan of the constituent entities of the Russian Federation, their composition and development procedure do not contain regulations concerning adaptation to climate change, which makes it difficult to obtain information at the regional level on the implementation of such measures in forest areas and the sustainability of forest plantations to the effects of climate change.

Thus, it is important nowadays to assess the planning and implementation effectiveness of adaptation measures in the Russian forest sector at the basic level; this is the level of the Forest Plan. The information obtained is needed to assess whether assessment indicators of the climate risk are objective and whether the forest sector can adapt to them at the level of forest planners and implementers of the constituent entities of the Russian Federation.

It should be noted that, in general, adaptation to climate change involves several groups of actors: research scientists; practitioners; decision-makers; analysts. The information from the forest plans
reflects the views, experiences and insights of the ‘practitioners’. Data from the ‘practitioner’ group (the Forest Plan data) are of particular value when considering the effectiveness of adaptation measures, as they come from the people who will implement the planned set of measures in practice.

As shown by numerous scientific studies [8-10], taken into account in regulations, the main risks to forestry due to climate change are as follows: changes in the productive capacity of forest ecosystems and species composition; increased fire danger levels; deterioration of forest pathology; and an increase in extreme weather events [11-13].

The adaptation measures to reduce or compensate for these risks are a set of forestry measures that need to be implemented according to the specific characteristics of the Russian Federation. Considering climate risks is particularly important for longer-term decision-making (with a longer-term planning horizon).

As stated above, since 2017, the forest plans of the constituent entities of the Russian Federation include information on measures to preserve the ecological potential of forests, adapt to climate change and increase forest resilience namely in paragraph 4.2 of the model form of the forest plan of the constituent entities of the Russian Federation. The results of the vulnerability and risk assessment for the specific forest management conditions of the constituent entity of the Russian Federation are recorded in Annex 21 ‘The Planned Measures for the Conservation of Ecological Potential of Forests, Adaptation to Climate Change and Increasing Forest Resilience’ of the forest plan of the constituent entities of the Russian Federation. They form the basis for an appropriate set of adaptation measures to reduce forestry's vulnerability and/or increase its adaptive capacity.

The authors have reviewed and analysed the forest plans of all the constituent entities of the Russian Federation. It has been established that the forest plans of 15 constituent entities currently lack information on planned activities to preserve the ecological potential of forests, adapt to climate change and increase forest resilience. Accordingly, the following regions were not included in the study of forestry adaptation planning practices: Belgorod, Voronezh, Kursk, Tula, Chelyabinsk, Sverdlovsk, Tyumen oblasts; Komi, Crimea, Dagestan, North Ossetia-Alania, Bashkortostan, Sakha (Yakutia); Krasnodar and Perm oblasts. The analysis of planned adaptation measures was based on information from the forest plans of 67 constituent entities, which were taken as 100% in the calculations.

3. Results and discussion

All constituent entities of the Russian Federation have a certain potential, level and capacity for development in each individual socio-economic area. The specifics of development of the regions of the Russian Federation in terms of their spatial (geographical), natural and climatic conditions, number and distribution of population in the territory, availability of transport infrastructure, number of production complexes and effective economic organisations, including innovative ones, ability to form the regional budget, determine, among other things, the list of risks for forestry in climate change and, consequently, the set of adaptation measures. Obviously, even the constituent entities in the same Federal District shall need to implement adaptation measures designed for each of them individually.

The basic forestry climate risks identified in the forest plans are as follows:
- Risk I – Change of the forest productivity because of changes in the average temperature and amount of precipitation;
- Risk II – Changes in forest species composition;
- Risk III – Increased frequency of forest fires and burned out areas;
- Risk IV – Increased frequency of massive pest outbreaks in forests;
- Risk V – Increased frequency of extreme weather events consequences in forests.

The analysis of forest plans showed that for all five baseline climate risks, reduction measures and adaptive capacity building were planned in all entities. All 65 reviewed constituent entities have planned adaptation measures for the Risk III ‘An increased frequency of (woodland) fires in forests and scorched areas affected by fires’. The lowest rate of planned adaptation measures is for the Risk V ‘An increased frequency of manifesting consequences due to extreme weather events in forest ecosystems’, however, 73% of all entities reviewed (figure 1) are planning measures to prevent or reduce them.
Figure 1. Percentage of the constituent entities of the Russian Federation with planned climate risk adaptation measures, %.

The results show that all risks are assessed by the entities as high potential threats to forestry, as more than 70% of the analyzed constituent entities consider them all in their forest plans. It is noteworthy that the risk of fire danger in forest ecosystems is assessed as one of the most likely and highest in all federal districts. Enhancing the adaptive capacity of forest ecosystems, in some cases, requires preventive measures. The Annex 21 of the Forest Plan proposes the implementation of fifteen types of adaptation measures for the five possible climate risks to Russian forest ecosystems:

The Risk I (Changes in productive capacity of forest ecosystems) in connection with changes in average temperature and amount of precipitation) provides for preventive measures of adaptation:
- Adjustment tending taking into account the productivity of forests;
- The adjustment of the list of species used in the processes of reforestation and afforestation;
- The adoption of measures for the use of quantities of dead and damaged trees;
- Diversification purposes of forest management to obtain forest products and services.

Adaptation to the Risk II (Changes in the species (breed) composition of forest ecosystems) provides for:
- An orientation to the cultivation of mixed plantings of different ages;
- The use of tree species adapted to predicted climatic changes in the processes of reforestation and afforestation;
- The formation of specially protected natural territories for the purpose of preserving vulnerable species and habitats;
- Identification and control of the number of invasive species of tree species.

The following measures are proposed for adaptation to the Risk III (An increased frequency of (woodland) fires in forests and scorched areas affected by fires):
- An improvement of the effectiveness of forest fire safety measures, including prevention of forest fires, monitoring of forest fire danger and forest fires;
- An adjustment of forest fire suppression plans due to the increased frequency of (forest) fires in forests and scorched areas affected by fires.

Adaptation measures to the Risk IV (An increased incidence of pest mass reproduction outbreaks in forests):
- An improvement of forest pathology survey;
- Improvement of measures to prevent the spread of pests.

Adaptation to the Risk V (An increased frequency of manifesting consequences due to extreme weather events in forest ecosystems) involves activities:
- An adjustment of the duration of the forest reproduction cycle in order to minimize the risks of windfall and wind-throw in forests;
- Improvement of timber harvesting technologies to minimize the risks of windfall and wind-throw in forests;
- A formation of mixed multi-storeyed stand plantations of various ages.

As noted above, each constituent entity of the Russian Federation, when solving the problem of forestry adaptation to climate change, plans a selective set of measures that are relevant specifically for it, taking into account the regional climatic and socio-economic conditions.

It can therefore be concluded that the lack of adaptation measures in forest plans for some kind of climate risk is a proxy for the resilience of the forest ecosystems of these regions to the effects of climate change.
A vulnerability assessment has shown that 27% of the Russian Federation entities are at risk of increased frequency of extreme weather events in forest ecosystems (figure 2). Approximately the same percentage of subjects (12-15%) are resistant to risks from changes in forest productivity, the species (breed) composition of woody vegetation and the risk caused by increased incidence of pest mass reproduction outbreaks in forests.

The resistance of forest ecosystems to the threat of forest fires during climate changes in all the studied subjects is zero. This means that when climate change occurs, fires pose the highest threat to forestry in all of the entities of the Russian Federation reviewed, which have incorporated adaptation measures to climate change into their Forest Plans.

Financial support for the implementation of adaptation measures because of the climate change in the forestry sector should be based on the principle of rational allocation of public funds while achieving the efficiency of their use to reduce climate risks. A diagram illustrating the distribution of planned financial resources for risk reduction by implementing measures to adapt forestry in the Russian Federation to climate change over the lifetime of the new forest plan (10 years) is shown in figure 3. Almost half of the total planned funding (48%) will be allocated to measures reducing the Risk I ‘Changes in productive capacity of forest ecosystems’. For the implementation of measures to prevent the occurrence of forest fires, it is planned to spend almost half the amount, namely 27%. It is bewildering taking into account that all constituent entities have rated the risk of fires as the highest one. The risks associated with the increased frequency of occurrence of the effects of extreme weather events and pest outbreaks are financially estimated to be the lowest. For their prevention and adaptation, 5% and 7% of the total funding is planned respectively, although the risks associated with outbreaks of forest pests and diseases were mentioned in the Forest Plans by 85% of the constituent entities of the Russian Federation (figure 3).

There is clearly no correlation between the amount of planned adaptation measures (across the constituent entities of the Russian Federation) and the projected cost of the work to implement them.

In this regard, it would have an advantage to distribute the planned amounts of funding for adaptation measures within each of the five types of risks. figure 4 shows the ratio of the proportion of Russian regions (per cent) that have planned adaptation measures to climate change risks to the proportion of funding for their implementation (in million rubles).
An analysis of the financial indicators of the Forest Plans revealed that a number of constituent entities do not provide funds for the implementation of adaptation measures or indicate that funding is accounted for by other works. Most of the constituent entities are not planning additional funding for the implementation of adaptation measures: identification and population control of invasive tree species (measure II.IV), adjustment of forest fire suppression plans (measure III.II) and improvement of timber harvesting technologies (measure V.II).

This may be due to the specific climatic conditions in the Federal Districts of the Russian Federation. At the same time, the validity of priorities for adapting to risk in some constituent entities probably needs to be refined and clarified.

To adjust plans for extinguishing forest fires in connection with an increase in their frequency, and the scorched areas affected by fires (adaptation measure III.II) for 63% of entities in total, 0.3% of the total amount of funding for the implementation of adaptation measures in forestry is planned. Almost all of these funds are supposed to be used in the Far Eastern Federal District. At the same time, the measure III.I ‘Improving the effectiveness of fire safety measures in forest ecosystems, including forest fire prevention, monitoring of fire danger in forests and forest fires’, which was planned by all of the reviewed constituent entities, is planned to allocate almost a quarter of the financial resources for the implementation of adaptation measures. It is clear that the constituent entities plan to focus their efforts and resources on implementing preventive measures to prevent fires from occurring in forests.

Amounts of financing planned for the implementation of measures to adapt to risks: II ‘Changes in the species (breed) composition of forest ecosystems’, IV ‘An increased incidence of pest mass reproduction outbreaks in forests’ and V ‘An increased frequency of manifesting consequences due to extreme weather events in forest ecosystems’ are relatively small. In particular, 1% of the total amount for adaptation is planned for a measure to improve the forest pathology survey system (adaptation measure IV.I), which is planned to be implemented by 79% of the constituent entities. Most of the funds for these purposes were planned by the constituent entities of the Central and Far Eastern Federal Districts. It seems that the task of improving forest pathology surveys is not very relevant for the constituent entities of the North-West and Ural Federal Districts. Alternatively, there is an underestimation of the danger of these risks in a number of regions.

The Forest Plans do not specify the timing and duration of the adaptation measures. It seems to be assumed that all adaptation measures envisaged in forest plans are pre-emptive and tactical.

Based on this analysis, it can be concluded that the forest plans of the constituent entities in the Russian Federation require additional detail on the level of vulnerability of forest ecosystems and clarification of priorities in the implementation of adaptation measures to climate change. At the same time the type of adaptation measures in terms of their timing, duration and scale, as well as who will implement them, should be taken into account.
Figure 4. The ratio of the amount of funding planned for adaptation measures under each of the five types of risks in the forestry sector of the Russian Federation under climate change: Forest care correction considering forest productivity (I.I), Correction of list of species used in forest restoration and cultivation (I.II), Taking measures in use of wood reserves of dead and damaged plantings (I.III), Diversification of forest management goals to obtain products and services (I.IV); Orientation to cultivation of multi-aged mixed plantings (II.I), Use of forest species adapted to climate changes in forest restoration and cultivation processes (II.II), Formation of specially protected natural territories to preserve vulnerable species and habitats (II.III), Detection and control of the quantity of invasive tree species (II.IV); Improvement of fire safety measures efficiency in forests, including prevention of forest fires, fire hazard monitoring in forests and forest fires (III.I), Correction of forest fire extinguishing plans due to increased frequency of forest fire and burned out areas (III.II), Improvement of forest pathology survey system (IV.I), Improving pest spread prevention measures (IV.II); Correction of forest reproduction cycle to mitigate risks of windfall deadfall in forests (V.I), Improvement techniques of timber harvesting to mitigate risks of windfall and deadfall in forests (V.II), Formation of multi-aged and multi-level plantings (V.III).

4. Conclusion
To date, the documents that contain indicators describing forestry adaptation measures to the effects of climate change are the forest plans of the constituent entities of the Russian Federation. They represent a baseline whose analysis of indicators makes it possible to assess the planning system and the effectiveness of the implementation of adaptation measures in the Russian forestry sector of the economy. It is noted that the Forest Plans do not specify the timing and duration of adaptation measures,
which makes it somewhat difficult to monitor the soundness of their choice and the effectiveness of their implementation.

At present, the forest plans of 15 constituent entities lack information on planned activities to preserve the ecological potential of forests, to adapt to the climate change, and to increase forest resilience. This fact needs to be taken into account and measures need to be taken to incorporate adaptation measures of the climate change into the forest plans.

An analysis of forest plans containing adaptation indicators shows that activities and events are planned that reduce and enhance adaptive capacity in all five-baseline climate risks. With climate change, fires pose the highest threat to forestry in all of the reviewed constituent entities of the Russian Federation.

A vulnerability assessment has shown that 27% of the Russian Federation entities are at risk of increased frequency of extreme weather events in forest ecosystems. Approximately the same percentage of subjects (12-15%) are resistant to risks from changes in forest productivity, the species (breed) composition of woody vegetation and the risk caused by increased incidence of pest mass reproduction outbreaks in forests.

There is no correlation between the scope of planned adaptation measures and the projected cost of the work to implement them. A number of constituent entities do not provide funds for the implementation of adaptation measures or indicate that funding is accounted for by other works. This may be due to the specific climatic conditions in the Federal Districts of the Russian Federation.

The forest plans of the constituent entities of the Russian Federation require additional detail on the level of vulnerability of forest ecosystems and clarification of priorities in the implementation of adaptation measures to climate change. At the same time the type of adaptation measures in terms of their timing, duration and scale, as well as who will implement them, should be taken into account. Obviously, even the constituent entities in the same Federal District shall need to implement adaptation measures exceedingly designed for each of them individually.

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