environmental sciences proceedings

MDPI

Proceeding Paper

Protected Areas as nature-based solutions for climate change adaptation†

Oksana N. Lipka [1]*, Alexandra P. Andreeva [1] and Tatiana B. Shishkina [3]

[1] Interconnection between the atmosphere and terrestrial systems research Department, Yu.A. Izrael Institute of Global Climate and Ecology, Glebovskaya St., 20-B, Moscow, 107258, Russia; olipka@igce.ru; andalexandrap@yandex.ru

[2] English Department, Institute for Social Sciences at the Russian Presidential Academy of National Economy and Public Administration (RANEPA), Municipal District Troparevo-Nikulino, Prospekt Vernadskogo, 82, building 1, Moscow, 119571, Russia; tanya.shishkina@gmail.com

* Correspondence: olipka@igce.ru; Tel.: +7-910-427-3740

† Presented at the 6th International Electronic Conference on Atmospheric Sciences (ECAS 2023) on 15-30 October, 2023.

Abstract: Protected Areas can play an important role in climate change adaptation as nature-based solutions. With the huge adaptation deficit, which results in an average of 60 billion rubles of losses from extreme weather events annually, the importance of protective ecosystem services is being underestimated. Conservation of intact vegetation enables maintaining stability in a territory several times larger, than within a Protected Area. In mountainous regions, forests and grasslands prevent mudflows. In tundra and high mountains, vegetation slows down the fast degradation of permafrost in a warming climate. Forests work to increase the minimum river low flow during droughts and to decrease the magnitude and pace of floods. Protected Areas provide territory and natural resources to indigenous people, so they can maintain their traditional lifestyle. It is of utmost importance to emphasize the value of Protected Areas as nature-based solutions by estimating the costs of the ecosystem services they provide and the amount of damage they help to avoid.

Keywords: climate change; Protected Areas; nature-based solutions; ecosystem services; ecosystem-based adaptation.

Citation: To be added by editorial staff during production.

Academic Editor: Firstname Lastname

Published: date

1. Introduction

In the 2020s, there is not a spot in the territory of Russia where climate change has not manifested to one degree or another. The rate of increase in the average annual temperature averages 0.6⁰C/10 years, and in Arctic it amounts to 1⁰C/10 years [1]. In the northern regions, the warming effect has favourable implications for the agriculture and forestry, as well as for people's health. However, as the climate is getting increasingly extreme, it is causing damage to all and every sector of the economy across the whole country [1,2,3]. Hazardous hydrometeorological events have grown in number from 150-200 per year in the late last century to 300-450 [1]. They annually cause more than 60 billion rubles in damage to the Russian economy [4].

Indigenous peoples are considered to be the most vulnerable to climate change, since their traditional lifestyle heavily relies on the environment and ecosystem services: hunting, fishing, reindeer husbandry, and the use of non-timber forest resources [2,5,6].

The global experience demonstrates the benefits of using ecosystem services and nature-based solutions as adaptation measures [2,7,8]. Protected Areas' intact ecosystems are the stabilization core and ensure protection from climatic risks. Thus, PAs contribute to the adaptation of the adjacent territories and can be viewed as Nature-based Solutions.

2. Methods

According to IUCN, Nature-based Solutions (NbS) are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature. Nature-based Solutions address societal challenges through the protection, sustainable management and restoration of both natural and modified ecosystems, benefiting both biodiversity and human well-being. They target major challenges, like climate change, disaster risk reduction, food and water security, biodiversity loss and people's health, and are critical for sustainable economic development [9,10].

Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change. EbA aims to maintain and increase the resilience and reduce the vulnerability of people and the ecosystems they rely upon in the face of the adverse effects of climate change [11]. It is viewed as one possible type of Nature-based Solutions.

For the purposes of adaptation to climate change it is convenient to use the classification of ecosystem services as developed by TEEB [12]. In Russia, this system was adapted and ecosystem services were assessed using three indicators: provided, required, and used volumes [13].

General information about PAs, and their distribution across the territory of Russia is provided based on Rosstat's data for 2022 [14]. The "Biomes of Russia" map [15] was used to obtain general information about the ecosystems, their biodiversity by the key systematic groups, and geographical distribution. Information about hazardous hydrometeorological events, to which the territory of a particular biome is exposed, was obtained from the database [16].

3. Adverse impacts of climate change

According to the observations, since the mid-1970s the warming rate in Russia has been about 2.5 times faster, than the global average. Throughout most of the country, there is a trend towards an increase in annual precipitation at a rate of 2.2% / 10 years (on average for 1976–2022); however, some areas (north of West Siberia, north of Chukotka) show a decline in annual precipitation. The evolution of precipitation by season in some Russia's regions is even more variable. In addition, climate change manifests through the increasing climate "nervousness", i. e. 1.5-2 times increase in the number of extreme (anomalous) weather events and their consequences (such as heat waves, droughts, floods, wildfires) compared to the end of the last century [1,3,17].

Model-based estimates of potential damages incurred by wind, frost, and strong precipitation during the cold and warm periods amount on average to 200 – 235 billion rubles per year. The most affected sectors include housing and communal (up to 70 billion rubles or more) and energy sector (64 billion rubles), followed by road transport (33 – 34 billion rubles). The estimate of the potential damage to agriculture is lower (20 – 22 billion rubles), which is explained by a lower cost of assets – agricultural crops in territories prone to droughts, including those combined with high temperatures [18].

4. Nature-based Solutions, ecosystem services, and Protected Areas

Nature-based Solutions use certain ecosystem services for climate change adaptation. PAs are one method of biodiversity conservation and maintaining the effective performance of ecosystem services, on the one hand, and one type of land use, on the other. By preserving intact landscapes Protected Areas help maintain the regulating ecosystem services, which have an important role in climate change adaptation and help reduce the risk of disasters (Figure 1).

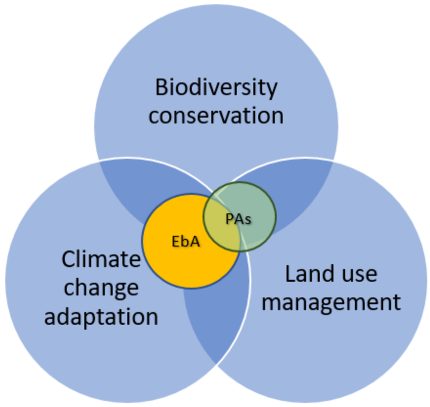

Figure 1. A conceptual model of integrating PAs into land use system, Nature-based Solutions, and climate change adaptation.

The classification of terrestrial ecosystem services in Russia [12] includes the following types which can be used for climate change adaptation and to reduce the risk of disasters: use of plants to reduce the wind strength and the damage caused by hurricanes and storms; regulation of moisture flows between the earth surface and the atmosphere; maintaining the volume of water runoff; regulation of variability (i. e. stabilization) of water runoff; reduction in the intensity of, and damage from, floods; protection of soils from water and wind erosion; prevention of dust storms; prevention of damage from landslides and mudflows; and regulation of cryogenic processes [19].

The range and scale of ecosystem services substantially differ across natural zones. The considerable extent of the country from north to south determines the wide range of successive ecosystems. More than 46 % of Russia's territory is covered with forest; around 65 % is permafrost, and 21.6 % is wetlands [20]. According to the "Biomes of Russia" map [15], more than 40 % of the territory is occupied with mountain biomes.

In permafrost areas, the removal of, and damage to, the vegetation provokes thermokarst processes, which then speed up through feedback loop and result in, *inter alia*, destruction of buildings and infrastructure in the Arctic region [21]. With well-developed vegetation and warming-propelled increase in peat and mosses, which are known for their cooling properties, the soil temperature remains stable [22].

Today, preservation, restoration, and adaptation of forests to climate change are viewed as an adaptation mechanism which can help reduce the damage caused by natural disasters to large areas, such as landscapes, river basins, etc. At that, forests form the backbone of these areas' environmental sustainability [23].

The ability of forest plantations to favourably influence the hydrological regime and temperatures has been long used in arid regions, primarily through creating forest shelterbelts. In Russia, these were first used in the late 19th century [24] and are still used now to reduce wind speed and increase snow reserves in the fields [25]. Typically, the wind speed reduction effect is 20 times the height of a shelterbelt on the downwind side and 5 times its height of the upwind side [26].

The records show, that 10-15% more precipitation falls annually over forested areas and adjacent parts of open spaces, than over the neighbouring bare areas [27].

Protection from heat waves, especially in urban heat islands, is an important challenge. Research shows, that air temperatures in urban residential neighbourhoods are 2.4-2.6^{o}C higher, than in urban parks. Parks also help mitigate excessive air dryness (relative air humidity in parks is 1.9-3.7 % higher) [28]. Reducing the thermal impact of the road topping materials by planting high shade trees along the pavements is one measure included in the draft climate change adaptation plan for Moscow [29].

In the northern regions, the warming effect of ecosystems is important to ensure comfortable living conditions. For example, the warming effect of swamps for Leningradskaya Oblast is estimated at 10% of the regional heat supply [30].

The impact provided by forests on the hydrological regime of rivers has three different dimensions: the effect on the water evaporation amount, on the surface and internal runoff, and on the water balance as a whole. In the bare areas in the middle of the East-European Plain, up to 65 % of annual precipitation comes to rivers with the surface runoff. 20 % afforestation of the territory can reduce the surface runoff to 14 %, and full afforestation brings it down to 5% [31].

Being also a soil protection factor, forests prevent soil washout with snowmelt and rainwater, protect soils from being blown away, and stabilize moving sands [32].

The extent to which ecosystems can provide an ecosystem service can vary significantly. For example, a slowdown in permafrost degradation or a decrease in erosion rate in polar deserts or high mountains is detected only compared to human-disturbed habitats, whereas vegetation cover in the taiga and tundra acts as insulation material preventing heat exchange. The effectiveness of using plants to fix slopes in the highlands varies by plant species and the structure of their root systems. At that, closed herbaceous-shrub canopy is as good as closed tree canopy.

However, adaptation measures, including Nature-based Solutions, have their limits: for example, ecosystem services cannot reduce the damage from ice crust formation or tornadoes. In these cases, it is practical to choose from other adaptation measures.

Since PAs are territories with minimally disturbed natural vegetation cover, they provide regulating ecosystem services to the maximum degree compared to other types of land use. The set of ecosystem services depends on the PAs' landscapes and the adverse climate conditions to adapt to. Albeit each PA has a certain specificity, the set of potential ecosystem services it provides can be presumed based on the natural zones and altitudinal belts to which it is confined. For all the large variety of adaptation ecosystem services, only two approaches are used to benefit from them: reducing the anthropogenic pressure and restoring the disturbed ecosystems. However, in each natural zone there is quite a large variety of Nature-based Solutions.

In this context, PAs have an important role to play being intact areas, where ecosystems are able to provide regulating services to the maximum degree for the purpose of climate change adaptation. According to Rosstat [17], in 2022, there were 11,931 PAs in Russia totaling to 2,442,698.08 km^2, which is about 14 % of the country's territory.

Albeit approaches to the valuation of ecosystem services, including those provided by PAs, have been developed for quite a long time [33,34], a comprehensive assessment for the whole Russia's territory has not been accomplished even in the framework of the National report prototype on the ecosystem services in Russia [12]. Some researchers confirm, that the entirety of ecosystem services provided may be 6 or more times more valuable, than the natural resources that can be harvested from 1 ha of PAs – timber, peat, etc. [35]. For example, the cost of pine stands in commercial forests amounts to 15,065 rubles/ha (production ecosystem functions) versus 124,640 rubles/ha in protection forests (regulating ecosystem functions), i. e. is more than 8 times lower [36].

5. Conclusions

The role of PAs in ecosystem-based adaptation and their potential as Nature-based Solutions is currently underestimated. One possible reason is the uncompleted overall assessment of the ecosystem services for the country. In addition, assessments of ecosystem services are typically made in compliance with the traditional TEEB system, which does not include many of the regulating ecosystem services that are important for adaptation.

However, even the available fragmentary estimates of PAs' adaptation ecosystem services show, that the ecosystem services they provide are at least 6 to 8 times higher in value, than the products that could be obtained from their territories. A complete evaluation would require analysis based on the basin approach, which implies the evaluation of damage prevention or reduction for all of the objects located downstream.

In order to highlight the value of Protected Areas as Nature-based Solutions for adaptation plans, it is critically important to assess the costs of the ecosystem services and avoided losses.

Author Contributions: Conceptualization, O.L., T.S. and A.A.; methodology, O.L. and T.S.; formal analysis, O.L., T.S. and A.A.; investigation, O.L. and A.A.; resources, T.S. and A.A.; data curation, O.L.; writing — original draft preparation, O.L., T.S. and A.A.; writing—review and editing, O.L. and T.S.; visualization, O.L. and A.A.; supervision, O.L. All authors have read and agreed to the published version of the manuscript.

Funding: The research was accomplished under state assignment from Russian Hydrometeorological Service No. AAAA-A20-120070990079-6 to Yu. A. Izrael Institute of Global Climate and Ecology.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. RF Service for hydrometeorology and environmental monitoring (Roshydromet). *2022 Report on the climate patterns in the territory of the Russian Federation*; Roshydromet: Moscow, Russia, 2023; 104 p.
2. IPCC. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]; Cambridge University Press: Cambridge University Press, Cambridge, UK and New York, NY, USA, 2022; 3056 p., doi:10.1017/9781009325844.
3. RF Service for hydrometeorology and environmental monitoring (Roshydromet). *Third Assessment Report on climate change and implications for the territory of the Russian Federation,* V.M. Katssov Ed.; Roshydromet: St. Petersburg, Russia, 2022; 676 p.
4. 60 billion rubles in damages from one-year extreme weather events in Russia. *Kommersant* **13.07.2020**, Available online: https://www.kommersant.ru/doc/4415915 (accessed on June 15, 2023).
5. IPBES. *The IPBES regional assessment report on biodiversity and ecosystem services for Europe and Central Asia*, Rounsevell M, Fischer M, Torre-Marin Rando A, Mader A. (eds.); Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: Bonn, Germany, 2018; 892 p. Available online: https://ipbes.net/assessment-reports/eca (accessed on June 1, 2023).
6. Bogoslovskaya L.S. *Indigenous peoples of the Russian North in the context of the global climate change and industrial development;* Center for assistance to indigenous peoples of the North: Moscow, Russia, 2015; Library of the indigenous peoples of the North series, Issue 16; 134 p.
7. IPCC. *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]; Cambridge University Press: Cambridge, UK and New York, NY, USA, 2019; 896 pp. Available online: https://doi.org/ 10.1017/9781009157988 (accessed on April 22, 2023).
8. Seddon, N., Chausson, A., Berry, P., Girardin, C. A., Smith, A., & Turner, B. Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philosophical Transactions of the Royal Society B* **2020**, 375(1794), 20190120
9. IUCN. Nature-based Solutions. Available online: https://www.iucn.org/our-work/nature-based-solutions (accessed on June 4, 2023).
10. Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.). *Nature-based solutions to address global societal challenges*. IUCN: Gland, Switzerland, 2016; xiii + 97pp. Available online: https://doi.org/10.2305/IUCN.CH.2016.13.en (accessed on May 4, 2023).
11. CBD. Recommendation adopted by the subsidiary body for scientific, technical and technological advice. Biodiversity and climate change: ecosystem-based adaptation approaches to climate change and disaster risk reduction. Twenty-second meeting. Montreal, Canada, 2-7 July 2018. Agenda item 9. Available online: https ://www.cbd.int/doc/recommendations/sbstta-22/sbstta-22-rec07-ru.pdf (assessed on 27 May, 2023).
12. TEEB. *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*, Pushpam Kumar Ed.; Earthscan: London and Washington, 2010; 456 p.
13. *Ecosystem services in Russia: National report prototype*. Vol. 1. Terrestrial ecosystem services, E.N. Bukvareva, D.G. Zamolodchikov Eds.; Wildlife Conservation Center: Moscow, Russia, 2016; 148 p.

14. Rosstat (RF Statistical Service). 2022 Data on protected areas. Available online: rosstat.gov.ru›storage/mediabank/1-OOPT_2022.xlsx (accessed on May 29, 2023).
15. The Biomes of Russia. Map 1:7 500 000. Moscow: Faculty of Geography Lomonosov Moscow State University, Russian Geographical Society, WWF-Russia; 2018. Available online: https://wwf.ru/en/resources/publications/booklets/karta-biomy-rossii-/- (accessed on April 14, 2023).
16. Lipka O. N., Shishkina T. B. Ecosystems: Climate Change Vulnerability and Resilience. *Environ. Sci. Proc.* **2022**, *19*(1), p. 58. https://doi.org/10.3390/ecas2022-12836 (accessed on March 12, 2023).
17. Lipka O.N. Distribution of hazardous weather events and their implications in Russia by biomes, their parameters Database. Registered by the Russian Service for Intellectual Property on 02.06.2023, certificate No. 2023621809.
18. RF Service for hydrometeorology and environmental monitoring (Roshydromet). Climate risks in the territory of the Russian Federation. Roshydromet: St. Petersburg, Russia, 2017; 106 p.
19. Oganesyan V.V., Sterin A.M., Vorobieva L.N. Potential damages from hazardous and adverse weather events in the territory of the Russian Federation: regional specificities. *Hydrometeorological research and projections* **2021,** No. 1; pp. 143-156.
20. Olchev A.V., Rozinkina I.A., Kuzmina E.V., Nikitin M.A., Rivin G.S. Estimating the impact of forest cover change in the central part of the East European plain on summer weather conditions. *Fundamental and Applied Climatology* **2017,** Vol. 4, pp. 79-101.
21. Eighth National Communication of the Russian Federation submitted in accordance with Articles 4 and 12 of UNFCCC and Article 7 of the Kyoto Protocol. Russian Ministry of Natural Resources and Roshydromet: Moscow, Russia, 2022; 345 p.
22. Petrov R.E., Karsanaev S.V., Maksimov T.Kh. The Stabilizing Role of the Shrub Layer of Tundra Biogeocenoses in the Russian Northeast. *Problems of regional ecology* **2022** (1), pp. 89-95.
23. Shpolyanskaya N.A., Osadchaya G.G., Malkova G.V. Climate warming and permafrost response in different landscapes (the case of Russian European North and West Siberia). *Proceedings of the All-Russian scientific and practical conference "Studying the hazardous natural processes and the geotechnical monitoring in engineering surveys"* **2022**, pp. 48-55.
24. Spathelf, P., Stanturf, J., Kleine, M., Jandl, R., Chiatante, D., & Bolte, A. Adaptive measures: integrating adaptive forest management and forest landscape restoration. *Annals of Forest Science*, *75* **2018**; pp. 1-6.
25. Rosenberg G.S., Saksonov S.V., Senator S.A. Belated experience of environmental reviews for global nature transformation plans in Russia. *Issues of steppe science*, No. 14 **2018**; pp. 15-35.
26. *National Report "Global climate and Russia's topsoil: estimating the risks and environmental and economic implications of land degradation. Adaptive systems and rational nature use technologies (agriculture and forestry)"*, A.I. Bedritsky Ed.; GEOS: Moscow, Russia, 2018; 357 p.
27. Belyuchenko I.S. The role of forest belt in agricultural landscape performance. In *Problems of recultivation of household, industrial and agricultural waste;* 2017; pp. 731-741.
28. Lugansky N.A., Zalesov S.V., Lugansky V.N. *The Forest Studies: Workbook*; Ural State Forest Engineering University: Ekaterinburg, Russia, 2010; 432 p.
29. Alyabysheva E.A. Analysis of microclimate parameters in various functional zones of Yoshkar-Ola. *Contemporary problems of medicine and natural sciences. Proceedings of the International scientific conference* **2019**; Mariysky State University: Yoshkar-Ola, Russia; pp. 264-265.
30. Draft Decree of the Moscow Government "On the approval of the list of measures for the adaptation of Moscow to climate change", 2023. Available online: https://www.mos.ru/eco/anticorruption/anticorruption-expertise/view/17982221/ (accessed on June 1, 2023).
31. Kulakovskaya V.A., Sanin A.Yu. Revisiting the economic assessment of ecosystem services provided by ecosystems of the Baltic coast. *Public Administration – Electronic Bulletin* (86) **2021**; pp. 115-140.
32. Likhomanov O.V., Bubnov D.V. Monetary assessment of the environmental functions of forests (the case of forests and forest stands in Volgograd Oblast). *Volgograd State University Bulletin. Series 3: Economy. Ecology, No. 2*; **2012**; pp. 214-220.
33. *Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis*. Island Press: Washington, DC; 155 p. Available online: http://www.millenniumassessment.org/documents/document.356.aspx.pdf (accessed on June 2, 2023).
34. Bobylev S.N., Zakharov V.M. *Ecosystem services and the economics*. Institute of Sustainable Development / Russian Centre for Environmental Policy and Culture: Moscow, Russia, 2009; 72 p.
35. Neverov A.V., Varapayeva O.A. Valuation of ecosystem services and biodiversity. *Proceedings of BGTU. Series 5: Economy and management* (7) **2013**; pp. 95-100.
36. Farber S.K., Martynov A.A., Sokolova N.V. Relative cost of the ecosystem functions of stands. *Interexpo Geo-Sibir, 4* **2022**; pp. 257-262.