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Environmental and Economic Assessment of Water Regulation Function of Rural Territories in the Republic of Komi*

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Abstract. The concept of sustainable development adopted in Rio de Janeiro in 1992 was a turning point in the understanding of the importance of "natural capital", when emphasis on ecosystem services was marked. An important step in the development of the practical use of the concept of ecosystem services was the decision, which is based on three principles: recognition of the ecosystem value; carrying out its economic assessment and the development of mechanisms accounting for these benefits. The article presents the ecological and economic assessment of water regulating function of the northern region on the basis of methodology of Yu.V. Lebedev and I.A. Neklyudov based on the evaluation of average annual growth rate of groundwater flow of forested watersheds. The region is situated in the natural zones of tundra and taiga. As for taiga forests, their precipitation joins groundwater flow during the period of summer and autumn rains. The differentiation of the value of groundwater flow is determined by the topography, forest cover, wetlands and characteristics of timber stands. The calculation also concludes that wooded watersheds provide the territory with water (as a result of the growth of the underground part of the river flow) by 130-560 cubic meters per hectare of forested areas in the summer period; the annual volume of accumulated water per hectare in the region is 9915,6

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million cubic meters, which may serve as a possible reserve of water in case of natural and man-made emergencies. The annual economic effect of water regulating role of forests is 3.5 billion rubles. This financial measure can be a starting point in assessing the damage from the loss of forested areas. The conducted evaluation is important because it provides specific data at the local level concerning forest ecosystem potential of keeping the amount of water differentiated by forestries.

Key words: water regulation function, groundwater flow, wooded watersheds, percentage of forest area, growth of groundwater runoff, forestry, ecosystem services, natural capital.

In connection with the increasing role of environmental factors in the world economy, issues concerning the preservation of environment and its biospheric functions in promoting the quality of life become more and more relevant. The concept for sustainable development, adopted in Rio de Janeiro in 1992 was a turning point in the understanding of the importance of "natural capital". This document introduced the term "ecosystem services", which has features common to those of natural capital. Often the terms "ecosystem services" and "biospheric functions" were used as synonyms when describing the value of the goods of nature, and only in recent years ecosystem "functions" have started to be treated as "services" if they entered the market. An important step in the development of the practical use of the concept of ecosystem services was a decision made in 2007 in Germany at the ministerial meeting of G8+5 on environmental protection. The decision is based on three key principles: recognition of the value of ecosystems, biodiversity; economic valuation; development of mechanisms to account for the services and benefits provided by ecosystems in the planning of economic activities [1]. In relation to ecosystem services there are three types of assessment: environmental (the ability of ecosystems to perform their functions); economic (integrated into the decision-making mechanisms familiar to the market) and social (ensuring consistent decisions for the community and removal of conflicts) [2]. Studies on economic valuation of biosphere functions of various natural objects (forest, wetland, etc.) are carried out not only abroad but also in our country. Thus, researchers at major Russian scientific centers like Lomonosov Moscow State University, RAS Institute of Market Problems, RAS Institute of Geography, RAS Institute for System Analysis, Institute of Plant and Animal Ecology of the Ural Branch of RAS, Botanical Garden of the Ural Branch of RAS and other research organizations and higher education institutions have analyzed and developed detailed schemes for practical application of the valuation for many years [3–8]. In recent decades, foreign researchers have developed various methods for the valuation of ecosystem services in monetary terms. They are described in detail in the works of S. Pagiola, D. Pearce, A. Freeman, W. Hanemann [9–11] and others. Existing methods are widely used, and their common feature is adherence to the principles of people's economic welfare.

It is known that forests maintain the balance of water in terrestrial ecosystems and regulate and improve river runoff. This paper presents an attempt to estimate the increase in water supply in the area by means of the underground component of river runoff and the economic effect of water regulating services of rural territories in the Republic of Komi. This issue is studied in rural areas of the region. Economic evaluation of water regulating services has a distinctive feature that consists in identifying the beneficiaries from the use of this good. In particular, this service can be considered at the local, regional and global level. Local users of this service are companies (various enterprises, business) and people interested in the availability of clean water. Regional (at the level of river basins) consumers are municipalities and economic agents (sectors) that use water, and the population and economic entities concerned in the prevention of floods and other negative effects [12]. Rural population, as well as industrial enterprises, is equally interested in the adequacy of not only water resources but also the ability to accumulate and hold the volume of water by forest ecosystems. It should be noted that major production sectors operating in rural territories of the region are agriculture and forestry, traditional nature management and the production of fuel and energy resources. In this case, forest area is an operating unit of rural areas.

Water regulating role of forests consists in the fact that they improve the balance between the incoming and outgoing parts of the flow by transferring surface runoff to groundwater runoff, this is how water is accumulated and preserved. Another effect is the reduction (but not prevention) of the intensity of floods in the period of snowmelt and heavy rains, increasing the level of water in the low-flow period, preventing the waterlogging of soils [13]. Scarcity of water resources for the region is not extremely urgent, as it can be observed, especially in recent years, in the other regions. However, preventing water crisis in many respects depends on effective forest management.

The state of forest resources. The region is located in the tundra and taiga natural zones, the vegetation on the western slope of the Urals forms mountain-forest, mountain tundra and goltsy altitudinal belts all this determines the region's distinctive features. Most of the territory is a sub-zone of middle taiga, which is dominated by spruce forest. As a result of fires and logging (for many decades), secondary spruce-birch, birch and aspen forests grow in place of coniferous forests and occupy large areas in the middle taiga subzone. The average forest cover in the republic is 79.1%, the highest values of this indicator (more than 90.0%) belong to the southern and south-western areas of the region, and the lowest (25–55%) – to the northern and north-eastern areas. Spruce is distributed on the territory of the republic unevenly, its predominance (60–80%) in coniferous forests is marked in the north-western and north-eastern forestries of Usinsky, Intinsky, Knyazhpogoststsky, Vuktylsky and Ust-Tsilimsky districts. A smaller percentage of spruce (30–40%) is observed in the central and southern forest districts of Priluzsky and Koygorodsky districts. The middle productivity class of spruce forests in the republic in general is[1] IV, 8; and in the middle subzone of the taiga it is IV, 5; in the southern zone it is III, 8. Second place among coniferous species in the republic belongs to the pine. Pine plantations occupy one fourth of the wooded lands of the republic (23.9%) and forest lands (25.2%). Forests of this species can be found throughout the republic, but their greatest areas are located on the upland terraces of major rivers (Vychegda, Pechora, and others). Pine plantations are most widespread (40–55%) in forestries of Syktyvdinskiy, Sosnogorsky and Ust-Kulomsky districts. Soft-wooded broadleaved species are represented by the birch, aspen, alder and willow, which account for 19.8% of the wooded lands of the republic, or 19.5% of the forest lands. It should be noted that since 2013 there has been a downward trend in the species conversion ratio, which is associated with the annual increase in the area of coniferous species transferred to the area covered by forests. Age structure of forests in the republic is a result of their long and uneven utilization and fires over the years. It is characterized by uneven distribution of plantations by age class for individual dominant species and for all forests in general. The republic in general is dominated by plants of age class VI and older (61% of the forested area). Mature and overmature plantations are located unevenly on the territory of the republic. For instance, in traditional logging areas along railways and public automobile roads, forest resources are depleted. The share of mature and overmature forests is negligible here. The main reserves of mature and overmature forests are concentrated in the north-western and north-eastern forest areas of the republic.

According to field studies [14], the hydrological role of taiga forests is manifested in the following:

- maximum moisture reserves are typical for spruce forests and the lowest – for birch forests; spruce forests have higher intensity of water accumulation and low intensity of reduction of water reserves in the soil, which significantly affects the amount and seasonal distribution of runoff of small rivers;
- with the increase in the forest cover of river catchments areas, the stocks of water in

[1] Actual data were taken from the State Report “On the state of the environment in the Komi Republic in 2015”. Syktyvkar, 2016. 173 p.

snow grow by the beginning of snowmelt; snow cover melting in spring is observed at a later stage (by 8–12 days);

- spruce forests contribute to the higher and prolonged standing of perched water (its level in forested watersheds is 2–3 times higher than in the area without forest vegetation).

Status of water resources. The river network of the territory under consideration belongs to the basins of the White (the rivers Vychegda, Luza, Mezen) and Barents (Pechora river) seas, and rivers that flowing directly into the sea. The total long-term average annual flow of the rivers in the study area is estimated at 228 km^3; it corresponds to the water flow of 7,230 m^3/s and an average runoff of 11.6 l/s*km^2 [14]. Its distribution in the basins of seas and major rivers of the region is presented in *Table 1.*

The river flow reaches its greatest depletion to the end of the season of the winter low water period: in the lowland rivers of the southern and central parts of the territory – in the first half of April; in the mountain and tundra rivers – in the first third of May.

The territory under consideration is swamped by an average of more than 10%; in the Far North, swamps in some places reach 60% of the area of river basins. The role of wetlands is manifested in the regulation of river flow, flow of water into lakes, and the maintenance of groundwater levels. When peat moisture is normal, bogs accumulate about 10 km^3 of water, including, up to 2–3 km^3 in the active layer. Studies have shown that logging activities in river catchments can have a significant impact on the change in the characteristics of river flow and hydrological regime of small rivers with a catchment area of 1–2 km^2. At small runoffs, the basins which were covered by continuous logging, you can expect a 20–25% reduction in annual runoff. The forestry component of changes in the runoff of medium and large

Table 1. Distribution of the long-term average annual runoff in the basins of seas and main rivers

Basin	Area, thousand km^2	Annual runoff		Flow rate, m^3/s	Modulus of flow, l/s · km^2
		km^3	% of the total		
White Sea, total	217	65.3	34.9	2070	9.51
Including: – river Vychegda	121	34.1	15.0	1080	8.90
– river Luza	18.3	4.23	1.9	134	7.30
– river Mezen	78.0	27.0	11.8	855	11.1
Barents Sea, total	404	163	65.1	5160	12.8
Including: – river Pechora	322	134	58.8	4250	13.2
– rivers of the sea coast	82.5	28.6	12.5	907	11.0
Total	**622**	**228**	**100**	**7230**	**11.6**

rivers of the region is relatively small. Here, the decrease in the value of this indicator caused by gradual (within the allowable cut) logging in the catchment areas does not exceed 1–5% [14]. Negative processes caused by forestry activities are expressed in the silting up of the rivers during the low-flow periods (which contributes to the changes in the qualitative and quantitative characteristics of fish resources), the increase in maximum water levels during spring floods, more intense development of erosion processes in river beds, etc. Modern types of mechanized logging are changing the forest environment. With the use of logging machinery on forest sites the ground vegetation and the upper soil horizons are badly damaged. As a result, water-physical properties and infiltration capacity of the soil are deteriorating. Soil properties deteriorate especially significantly after application of the tractors with a high specific pressure on the ground in the snowless period. After the use of such machinery on loamy and clayey wet soils their permeability is reduced dozen-fold. Dramatic deterioration of water-physical soil properties leads to a complete loss of water protective functions of forest areas affected by logging. The coefficient of surface runoff increases in more than 200 times, subsurface flow completely disappears and the intensity of water erosion is increased hundreds of times [15]. Due to the fact that during the summer logging the litter is removed and water-physical properties worsen, the soil freezes to a great depth and it usually does not have time to thaw out before the complete disappearance of the snow cover. Therefore, the entire spring runoff flows across the surface and impairs the hydrological regime of rivers.

Economic assessment. The concept of total economic value that originated in the 1990s is the most common practice in the world for conducting economic evaluation.

Table 2. Algorithm of calculating total economic value

Formula	**TEV= DV + IV + OV + EV**			
Items	Direct use value (DV)	Indirect use value (IV)	Option value (OV)	Existence value (EV)
Examples	Fishing Hunting Agriculture Recreation Gathering Fuel (peat)	Carbon sequestration Wastewater treatment Preservation of microclimate Pollination Assimilation Water management	Potential future use (both direct and indirect) The opportunity of obtaining goods and services in the future	Biodiversity Inheritance Culture
Methods	Method of “market” prices Costly methods Method of transportation costs	Method of “market” prices Costly methods (compensation costs) Method of subjective assessments	Method of subjective assessments (“willingness to pay” for the preservation of the resource)	Method of subjective assessments Hedonistic method Method of transportation costs

* The table was made with the use of the monograph:Tishkov A.A. (Ed.). *Ekonomika sokhraneniya bioraznoobraziya* [Economics of biodiversity conservation]. Moscow: GEF proyekt “Sokhraneniye bioraznoobraziya”; Institut ekonomiki prirodopol’zovaniya, 2002. 604 p.

The main idea of this concept is based on the resource, regulating and cultural functions of natural capital. The total value consists of the value of the use and of the non-use of the territory that has the functions of natural capital *(Tab. 2)*. In this case, it is objectively difficult to assess the water regulating function and, in our opinion, it is possible only to designate the lower boundary here.

For example, when evaluating the regulation of the composition of hydrological parameters included in the environment forming function, we used a technique developed by researchers at the Botanical Garden of the Ural Branch of RAS, taking into account the bogginess and woodiness of the territory, the structure of the forest, bonitet, forest stand, and the proportion of summer precipitation [13, 16, 17]. Assessment in a particular case was conducted broken down by the forestries of the region.

Evaluation of water regulating function. Forested watersheds allow for transferring up to 95% of river runoff to the underground part, whereby in the future the territory can be evenly provided with water resources [13]. Water regulating function dependent on the increase of underground runoff is estimated by the following formula [16]:

$$\Delta S = X \cdot \alpha \cdot K_1 \cdot \mu \cdot [C_1 \cdot K_2 \cdot K_3 \cdot K_4 - C_2], \quad (1)$$

ΔS is the annual average increase of underground runoff, mm;

X – average annual precipitation[2], mm;

α –river runoff ratio;

μ – share of summer precipitation[3], %;

K_1 – bogginess ratio[4];

C_1 and C_2 – ratios of the underground runoff of forested and woodess areas;

K_2 – ratio characterizing the age of the plantings;

K_3 – coefficient characterizing the bonitet class of the plantings;

K_4 – coefficient depending on the fullness of the plantings.

The value of river runoff ratio (α) is determined depending on the natural zones of vegetation areas (by subzones of taiga) and terrain (mountains and plains). Their values are taken according to the data of Yu.V. Lebedev and I.A. Neklyudova and range from 0.14 to 0.56; the minimum values are in the southern subzone of taiga, and the maximum are in the mountainous part of Far North taiga [3, 17]. The values of the ratios of the underground runoff of forested and woodess areas depend on forest cover (%), type of planting (deciduous or coniferous) and mechanical composition of soils (loamy or sandy) [17]. The values of bogginess ratio are

[2] SNiP construction rules and regulations 23-01-99. Table 2. Climatic parameters of the warm period of the year. Russian Federation. Kemerovo Oblast, Kirov Oblast, Komi Republic, etc. and SNiP construction rules and regulations 23-01-99. Building climatology. Table 1. Climate parameters of the cold season of the year. Russian Federation. Kemerovo Oblast, Kirov Oblast, Komi Republic, etc.

[3] *Ibidem.*

[4] *Atlas Respubliki Komi* [Atlas of the Komi Republic]. Moscow: Feoriya, 2011. 294 p.

in inverse proportion to the bogginess of the territory itself: the higher the bogginess, the smaller the value of this ratio (0.85–1.00). The values of coefficients characterizing the age (0.25–1.00) and fullness of the plantings (0.65–1.0) have a direct correlation: the older the age of the plantings and the higher the fullness of the plantings, the higher the value of this ratio [18]. And vice versa – the higher the class of bonitet, the smaller the value of the corresponding ratio (0.6–1.3).

Let us demonstrate the procedure on the example of calculating the magnitude of the increase in underground runoff per ha over the summer period for the mature stands on the Pechora forestry (the total area of which is 4,256.8 thousand ha). Conifers dominate here and account for 82.8% of plantings, of which young growths constitute 1.8%; mid-ripening – 15.0%; ripening – 16.1% and ripe – 67.1% (data on the forest management of the forestry[5]). The annual precipitation is 473 mm (data of SNIP, Petrun station for weather observations); river runoff ratio is 0.5 (flat terrain, Far North taiga); the share of summer precipitation is 0.74 (data of SNIP, Petrun station for weather observations); bogginess ratio – K_1 (for the bogginess of the territory equal to 7.6%[6]) equal to 0.9 is taken from the table in [18]); the ratio of the underground runoff – C_1 (accepted by the forest cover (54%), pine plantations, lowland forests and loamy soils) is equal to 0.65 [16]; the ratios of the underground runoff of woodless areas C_2 is 0.12 [18]; the ratio characterizing the age of the plantings K_2 (for calculation of mature stands of bonitet class V) is 1.0; the coefficient of bonitet class K_3 (bonitet class V) is 0.6 [18]; the coefficient of the fullness (0.4) of plantings K4 is taken equal to 0.7 [18]. Thus, substituting the values of the presented indicators, we get the value of groundwater gain per ha for mature stands:

$$\Delta S = 473 \cdot 0{,}5 \cdot 0.74 \cdot 0.9 \cdot [0.65 \cdot 1{,}0 \cdot 0.6 \cdot 0{,}7 - 0.12] = 24{,}09 \text{ mm or } 240.9 \text{ m}^3/\text{ha}$$

For other categories of plantations of coniferous and deciduous species (of different categories) we conduct similar calculations. Given the equity distribution of plantings (82.8% for coniferous species; 17.2% for deciduous species), we calculate the total increase for the forestry in general. In our case, it is 209.6 m^3/ha. The volume of water accumulation taking into account the area of the forestry is 292.2 million m^3.

In order to determine the economic impact of water regulating function, it is necessary to choose the financial equivalent. It can be presented by utility bills for water usage and water tariffs for industrial enterprises. These indicators for the Republic of Komi vary throughout municipal districts and the basins of Pechora and Northern Dvina. Thus, the average value of water tariff (utility fee for the use of cold water) in the region is 40 rubles/m^3, the value of the

[5] According to the Forest Committee of the Komi Republic (Komileskhoz) by forestries of the region.

[6] *Atlas Respubliki Komi* [Atlas of the Komi Republic]. Moscow: Feoriya, 2011. 294 p.

Table 3. Evaluation of the water regulating function of the region broken down by forestries

Forestry	Area, thousand ha	Increase in groundwater runoff, m³/ha	Structure of plantings C/D, %	Water accumulation volume, mln m³	Economic effect, mln rub.
Southern forest tundra, Far Northern taiga,					
Pechorskoe	4256.8	209.6	83/17	892.2	303.9
Usinskoe	2990.4	156.2	88/12	467.1	159.1
Ust-Tsilemskoe	4037.1	309.5	86/14	1249.5	425.5
Izhemskoe	1754.3	560.4	85/15	983.1	334.8
Northern taiga					
Kadzheromskoe	1295.4	334.8	92/8	433.7	147.7
National Park	567.8	182.4	44/23	103.6	35.3
Vuktylskoe	1306.9	400.8	91/9	523.8	178.4
Sosnogorskoe	1618.5	325.8	82/18	527.3	179.6
Ukhtinskoe	1280.1	330.1	78/22	422.6	143.9
Middle taiga					
Meshchurskoe	1162.2	157.9	88/12	183.5	160.9
Udorskoe	1475.2	335.9	90/10	495.5	101.1
Ertomskoe	1109.4	280.7	86/14	311.4	86.8
Mezhdurechenskoe	958.8	278.8	80/20	267.3	59.6
Zheleznodorozhnoe	1445.4	362.2	76/24	523.5	170.0
Aikinskoe	390.4	179.9	63/37	70.2	22.8
Chernamskoe	83.6	315.9	86/14	26.4	8.6
Storozhevskoe	835.9	214.3	78/22	179.1	39.5
Pomozdinskoe	680.9	243.4	82/18	165.7	8/.3
Troitsko-Pechorskoe	951.4	269.5	75/25	256.4	120.9
Pechoro-Ilychskoe	1179.6	300.9	94/6	354.9	48.8
Natural reserve	721.3	198.8	88/12	143.4	112.7
Komsomol'skoe	1134.2	291.8	89/11	331.0	83.8
Ust-Nemskoe	1002.1	257.4	82/18	257.9	40.7
Ust-Kulomskoe	426.8	293.8	64/36	125.4	39.9
Pruptskoe	483.1	254.2	69/31	122.8	53.8
Lokchimskoe	405.7	249.0	62/38	101.0	58.2
Kortkerosskoe	475.9	154.6	73/27	73.6	32.8
Kazhimskoe	408.8	406.9	69/31	166.3	54.1
Koigorodskoe	618.1	336.6	65/35	208.1	98.2
Sysolskoe	579.1	418.1	66/34	242.1	25.0
Syktyvkarskoe	195.6	394.2	80/20	77.1	17.5
Syktyvdinskoe	478.9	254.1	74/26	121.7	45.0
Southern taiga					
Letskoe	428.9	125.5	44/62	53.8	67.6
Priluzskoe	810.2	170.9	55/45	138.5	78.6

tariff changes in the range of 29–182 rubles/m^3 [19]. These calculations use the fee that industrial enterprises pay for the use of water, the amount of the fee is regulated for the basins of the rivers: for Pechora basin – 258 rubles/thousand m^3; for Severnaya Dvina basin – 246 rubles/thousand m^3 with the multiplying coefficients[7] of 1.32 for 2016. On the example of Pechora forestry (basin of the river Pechora), we see that the economic effect is expressed as the product of the volume of accumulation of water by the fee for the use of water for industrial enterprises (258 rubles/thousand m^3 * 1.32) and it is equal to 303.9 million rubles.

Usually, when calculating the increase in groundwater flow, the key indicator is the average annual rainfall, which, due to the characteristics of the forested area, is able to retain and accumulate moisture. The amount of precipitation depending on the natural zones of vegetation increases from the southern taiga to the zone of the Far North. Often, however, the proportion of forest cover and the structure of plantings (deciduous or coniferous) and their age are more significant due to the adjusting factors. These characteristics determine the difference in the forestries located in the same vegetation zones. For example, in the area of Far North taiga for Usinskoe and Ust-Tsiemskoe forestries, due to differences in the proportion of forest cover and average annual rainfall, the twofold difference in the volume of increase in groundwater flow is observed *(Tab. 3)*. The table presents the results of calculations of the annual economic effect of the water regulating services of the region broken down by forestries and natural areas of vegetation.

The increase in groundwater flow characterizing the amount of storage of water, correlates to the greatest extent with the following parameters: annual rainfall; forest cover of the territory; proportion of conifers in the structure of forested areas; proportion of ripe species (coniferous and deciduous). Thus, the higher values of these parameters, the greater the increase in groundwater flow. Forests and forested watersheds fulfill a critical ecological role by maintaining the natural hydrological regime in the region. Thus, for the summer period, forested watersheds provide water to the area (due to the growth of the underground component of river runoff) of 130–560 m^3 per hectare of forested area – the annual volume for the region is 9,915.6 million m^3. The annual economic effect of the water regulating role of forests is 3.5 billion rubles *(Tab. 4)*.

This financial indicator can serve as a starting point to assess the damage from the loss of forest-covered areas, and the quantitative indicator shows the possibilities of water storage to organize water-intensive industries.

[7] Resolution of the Russian Government “On the rates of payment for the use of water objects being in the federal property” dated December 30, 2006 No. 876 and the Resolution of the Russian Government “On the rates of payment for the use of water objects being in the federal property and on amending Section 1” dated December 26, 2014 No. 1509.

Table 4. Economic effect of water regulation function of rural territories of the region broken down by natural zones of vegetation

Natural zone	Area, thousand ha	Ratio of coniferous to deciduous species, %	Показатели		
			Increase in groundwater runoff, m³/ha	Water accumulation volume, mln m³	Economic effect, mln rub.
Southern forest tundra, Far Northern taiga	13 040	85/15	150-560	2907.8	1223.3
Northern taiga	6 070	85/15	180-400	2011.0	684.9
Middle taiga	17 200	75/25	150-420	4804.5	1480.7
Southern taiga	1 240	50/50	130-180	192.3	146.2
Total for the region	**37 550**		**130-560**	**9 915.6**	**3 535.1**

Practical importance of assessing the service. Currently, areas of practical application of ecosystem services assessments have been formed [7, 20-23], the major ones are as follows:

- designing national environmental policy and long-term programs and plans for environmental protection with the aim of reducing the level of environmental threats;
- incorporating the value of ecosystem services in the national systems of integrated environmental and economic accounting, the system of national accounts, the estimation of adjusted indicators of GRP and others;
- establishing fees and insurance premiums;
- establishing a market for ecosystem services.

The most important condition of effective management in the natural resource sector is the organization of its provision with scientifically substantiated information on natural reserves and on income obtained. In 1993, the UN Statistics Division introduced the System of Environmental-Economic Accounting (SEEA) consistent with the System of National Accounts (SNA). The accounts of the SNA are accounts of flows that reflect the cross-cutting movement of goods, services and income through all the stages – from production to use. Most national statistical forms relating to natural capital present the data in physical terms rather that in value terms as it is required by the SNA. It should also be noted that environmental management in the sector of households is not reflected in the system of statistics observation. Changing this system with a mandatory monitoring of the economic value of natural capital, including the household sector, would allow for the planning of regional development taking into account the interests of population, creation of new jobs and alleviation of poverty [21]. Some efforts to consider environmental issues in economic development of Russia's regions were undertaken in the framework of a project carried out by WWF-Russia on the development of an environmental-economic index for regions, taking into account environmental sustainability (including environmental, economic and social factors). The standard system of national accounts assumes that only investments in fixed capital are investments in the future welfare of society. Broader definition of adjusted net savings includes natural and human capitals that constitute national wealth. From this perspective, the depletion of nonrenewable natural resources and the overuse of renewable natural resources represent a deduction from the national wealth [6]. The adjusted net savings index characterizes the rate of accumulation of national savings after proper accounting of natural resource depletion and damages due to pollution. The index is a result of changes in gross domestic savings. Adjusted net savings (ANS) for Russian regions are calculated according to [24] by the formula (2):

$$ANS = GFCF - IFC - DNR - PDE + \\ + BEHCD + EEP + ASPNA, \qquad (2)$$

where GFCF stands for "gross fixed capital formation";

IFC – for "investments in fixed capital by type of activity "Mining";

DNR – for "depletion of natural resources";

PDE – for "pollution damage to the environment";

BEHCD – for "budget expenditures on human capital development";

EEP – for "expenditures on environmental protection";

ASPNA – for "assessment of specially protected natural areas".

Among the restrictions, imposed in connection with the use of official statistics, it is necessary to note a low efficiency of the published data (for some indicators, information is published with two-and sometimes three-year delay). It should be noted that domestic developments concerning the valuation of ecosystem services currently concern specially protected natural areas, where the environment-forming, provision and cultural functions of natural capital are taken into account. It is therefore necessary, in addition to the costs of environmental protection activities provided for at the objects of federal importance (through state funding, which in 2014 amounted to 320.4 million rubles), to take into account the value of these natural functions/services. So, we have assessed major sites of protected areas (of regional importance), where the specific indicator of value varies according to the degree of demand among tourists, according to natural environmental conditions, etc. and is equal to 10–990 rubles/ha per year [23]. According to expert estimates, the average value for all protected areas this indicator can make 500 RUB/ha/year. Thus, taking into account the total area of all protected areas in the region, which is 2.7 million ha, the value of these sites, taking into account ecosystem functions, is 1 350 million rubles.

Expenditures on environmental protection, according to the statistics for the region[8] as of 2014 comprise 76.7 million rubles. The damage from environmental pollution is determined by the amount of payments for negative impact on the environment (for 2014 – 1053.3 million rubles to the consolidated budget of the region). Budget expenditures on human capital development comprise 52194.5 million rubles (according to the same statistics as of 2014). Investments in fixed capital by type of activity "Mining" were 21.04 billion rubles. The depletion of natural resources consists of two components: mineral resources component and forest component. The depletion of the mineral resources (DMR) is estimated by volume of gross value added by type of activity "Mining" and is 89.0 billion rubles. Forests are renewable natural resources, and in some regions there is a situation where the volume of timber harvesting or the reduction of its reserves due to other causes, such as fires, may be lower than its growth. In this case the natural resource is not exhausted, but replenished. In this regard, when assessing the impact of changes in the stock of forest resources (CSFR) on the amount of net savings, the following principle is used: if timber supplies are reduced, then net savings are reduced by the cost of the reduced amount of wood, if timber supplies increase, so do net savings. Therefore, the value of CSFR can take positive and negative values: if timber stock increases, then the value of CSFR is negative, and vice versa [24]. The change is calculated relative to the average value of timber reserves in recent years. The cost of changes in timber reserves in the region is determined based on the price of round timber to produce lumber. According to statistics, the change in timber reserves in the region amounts to 19.4 million m^3, while the average price of timber for production of lumber is 968.3 RUB/m^3. Thus, the depletion of forest resources is 18.8 billion rubles. Gross fixed capital formation (net savings) comprise 112.89 billion rubles.

$$\begin{aligned} ANS &= 112.890 - 21.040 - 107.800 - \\ &- 1.053 + 52.195 + 0.077 + 1.650 = \\ &= 37.97 \text{ billion rubles.} \end{aligned}$$

The environmental-economic index (adjusted net savings index – ANSI) is calculated as the ratio of adjusted net savings to GRP by the formula (3):

$$ANSI = ANS/GRP \cdot 100\%, \qquad (3)$$

where ANS stands for "adjusted net savings";

GRP – for "gross regional product" (according to statistics of the region as of 2014m it is 469.6 billion rubles).

The value of adjusted net savings index for the region is 8.09, which, given the "positive values" in the group of export-oriented regions of the country, already proves that the territory is moving along the path of sustainable development.

[8] *Informatsionno-analiticheskii obzor "Respublika Komi. Itogi 2014": stat. sb.* [Information and analytical review "Komi Republic. 2014 results": statistics collection]. Syktyvkar, 2015. 260 p.

At the microeconomic level, the assessment of environmental (association of regulatory and supporting services) functions of an ecosystem involves determining the damage caused by their deterioration and the volume of resources to replenish or prevent them [25]. According to G.A. Motkin's opinion, an available compensatory mechanism can be found in the insurance of the risk of violation of environmental functions. In particular, researchers at the Central Economics and Mathematics Institute, RAS proposed a set of measures for replacing the existing "payments for negative impact" with "insurance payments", the amount of which would not go to the budgets, but would be collected at the enterprises themselves. The calculation of such payments was proposed to be determined on the basis of the value of ecosystems that are affected by activities of the enterprise. There are practical developments on tariff rates of insurance contributions for insurance against the risk of violation of ecosystem functions, depending on economic sectors [26, 27].

The formation of ecosystem services market in Russia is not yet developed; as for foreign countries, the situation is opposite there. The most common payments for ecosystem services in foreign countries are those relating to forestry and agriculture, where the main principle is "it is not the polluter, but the user, who pays". According to the definition of the United Nations Economic Commission for Europe (2007), payment for ecosystem services means "contractual transaction between a buyer and a seller for an ecosystem service, or a land use/management practice likely to secure that service" [27]. As a rule, it concerns biodiversity, water resources (preserving their quality) and carbon emissions. At the same time, the purpose of such payments is to gain maximum social benefit at existing market incentives. As of 2011 in Europe, North America and Central Asia, many schemes have been developed (78 schemes, of which 37 deal with forests, 28 deal with watersheds, and 13 serve to ensure water quality) for agricultural and forest areas [28]. For example, in Sweden and Finland, compensation is paid (by state authorities) to private forest owners for the protection of part of their lands rather than for their exploitation. In Latvia, for example, a fee is charged for using hiking trails – it is an example of *governmental schemes*.

In the case when relations are established between private companies (for example, between farmers or forest owners and industrialists) to ensure groundwater quality through the abandonment of economic activity, it is an example of *private schemes*, as well as the repurchase of agricultural land from farmers with the aim of making them into protective forests, etc.

Banking schemes (or compensation schemes) are applied as a tool to reduce climate change – according to the Clean Development Mechanism expressed in the afforestation of areas for the sequestration of carbon emissions (Georgia, Moldova, Albania, etc.)

Private-public schemes include the building of relationships between private owners (forest owners and farmers) and state-owned corporations, when the corporation collects higher tariffs (e.g. for water) and transfers part of the funds to these owners for the maintenance of groundwater quality so that they could reduce fertilizer application and replace coniferous with deciduous species.

Differences in the organization of natural resource management, in the monitoring of a strict compliance with laws and regulations, as well as differences in forms of ownership of natural resources in Russia and other countries determine the possibility of implementing many schemes for preserving the ecosystem services in the territories. However, the assessment of their value can be the starting point for their preservation and consideration in the planning of perspective natural resource management in Russia. The greatest distribution of such practices in Russia is observed in the recreational resources located on a specially protected natural area. Thus, initial developments concerned the arrangement of sustainable nature use on the territory of protected areas of Kamchatka, Altai Krai, the Smolensk and Kaluga oblasts, the Lower Volga area, and the Komi Republic. In the first phase of managerial decision-making, an economic assessment of the value of these areas was carried out and the recipients of benefits from the use of ecosystem services were determined. Further on, business plans for development of specific sites were worked out, they were based on the inclusion of tourist, agricultural and sports sectors of the economy and traditional economy. Taking the region under consideration as an example, we have presented an algorithm for evaluating the efficiency of development of protected areas based on an assessment of the value of ecosystem services [23].

World research on the assessment of natural capital significantly enhances the understanding of the value of ecosystems. Even despite the fact that the approaches and methods of assessment are still evolving and many of them are far from being perfect, they can provide a quality assessment of the benefits and costs associated with changes in environmental quality. The evaluation that we have conducted is important due to the fact that it provides specific data at the local level in the region on the potential of forest ecosystems to retain the volume of water differentiated by forestries. These calculations are necessary for the development of regulatory mechanisms, since the evaluation of natural capital forms the basis of many economic tools.

References

1. Konyushkov D.Ye. Formirovaniye i razvitiye kontseptsii ekosistemnykh uslug: obzor zarubezhnykh publikatsiy [Formation and development of the concept of ecosystem services: a review of foreign publications]. *Byulleten' Pochvennogo instituta im. V.V. Dokuchayeva* [Bulletin of V.V. Dokuchaev Soil Science Institute], 2015, no. 80, pp. 26-49. (In Russian).

2. Jacobs S., Dendoncker N., Keune H. (Eds.). *Ecosystem Services. Global Issues, Local Practices.* Elsevier, 2014. 411 p.

3. Lebedev Yu.V. *Otsenka lesnykh ekosistem v ekonomike prirodopol'zovaniya* [Assessment of forest ecosystems in environmental economics]. Yekaterinburg: UrO RAN, 2011. 575 p. (In Russian).

4. Krasovskaya T.M. *Prirodopol'zovaniye Severa Rossii* [Nature management in the North of Russia]. Moscow: Izd-vo LKI, 2008. 288 p. (In Russian).

5. Tishkov A.A. (Ed.). *Ekonomika sokhraneniya bioraznoobraziya* [Economics of biodiversity conservation]. Moscow: GEF proyekt "Sokhraneniye bioraznoobraziya"; Institut ekonomiki prirodopol'zovaniya, 2002. 604 p. (In Russian).

6. Bobylev S.N., Perelet R.A., Solov'yeva S.V. *Otsenka i vnedreniye sistemy platezhey za ekosistemnyye uslugi na osobo okhranyayemykh prirodnykh territoriyakh: metodicheskiye rekomendatsii* [Evaluation and implementation of a system of payments for ecosystem services in protected natural areas: methodological guidelines]. Volgograd, 2012. 176 p. (In Russian).

7. Fomenko G.A., Fomenko M.A., Mikhaylova A.V., Mikhaylova T.R. *Ekonomicheskaya otsenka osobo okhranyayemykh prirodnykh territoriy Kamchatki: prakticheskiye rezul'taty i ikh znacheniye dlya sokhraneniya bioraznoobraziya (na primere prirodnogo parka "Bystrinskiy")* [Economic evaluation of protected territories of Kamchatka: practical results and their importance for biodiversity conservation (case study of "Bystrinsky" Natural Park)]. Yaroslavl: ANO NIPI "Kadastr", 2010. 156 p. (In Russian).

8. Puntsukova S.D. *Formirovaniye ekonomicheskogo mekhanizma ustoychivogo lesopol'zovaniya v regionakh s ekologicheskimi ogranicheniyami* [Formation of the economic mechanism for sustainable forest management in regions with environmental restrictions]. Novosibirsk: GPNTB SO RAN, 2012. 335 p. (In Russian).

9. Freeman A.M. *The Measurement of Environment economic and Resource Values: Theory and Methods. Second edition*. Washington: Resources for the Future, 2003.

10. Hanneman W.M. "Willingness to pay and willingness to accept: How much can they differ?" *American Economic Review,* 1991, no. 81 (3), pp. 635-647.

11. Pearce D., Turner K., Bateman J. *Environmental Economics. An Elementary Introduction.* Baltimore: The John Hopkins University Press, 1993.

12. *Ekosistemnyye uslugi nazemnykh ekosistem Rossii: pervyye shagi. Status Quo Report* [Ecosystem services of terrestrial ecosystems of Russia: first steps. the Status Quo Report]. Moscow: Tsentr okhrany dikoy prirody, 2013. 45 p. (In Russian).

13. Anufriyev V.P., Lebedev YU.V., Neklyudov I.A. Vodookhrannaya rol' lesov: ekonomicheskiy aspekt [Water conservation role of forests: the economic aspect]. *Vestnik Ural'skogo otdeleniya RAN* [Bulletin of the Ural Branch of the Russian Academy of Sciences], 2013, no. 4, pp. 31-39. (In Russian).

14. *Vodnyye resursy i upravleniye vodopol'zovaniyem na Yevropeyskom Severo-Vostoke* [Water resources and water management in the European North-East]. Syktyvkar, 2011. 324 p. (In Russian).

15. Krestovskiy O.I. *Vliyaniye vyrubki lesa na vodnost' rek i vosstanovleniye lesov* [Effect of deforestation on the water content of rivers and restoration of forests]. Leningrad: Gidrometeoizdat, 1986. 117 p. (In Russian).

16. Neklyudov I.A. Metodika otsenki vodoreguliruyushchey roli lesopokrytykh vodosborov [Method of evaluation of the role water regulation forested watershed]. *Lesa Rossii i khozyaystvo v nikh* [Russian forests and their economy], 2011, no. 1, pp. 81-83. (In Russian).

17. Neklyudov I.A. Ekologo-ekonomicheskaya otsenka vodoreguliruyushchey roli lesopokrytykh vodosborov Srednego Urala [Ekological-economic assessment of the water regulating role of forested watersheds of the Middle Urals]. In: *Problemy obespecheniya razvitiya sovremennogo obshchestva. Sbornik trudov mezhd. n-prakt. konf. UFU im. B. Yel'tsina, IE UrO RAN* [Problems of development of modern society: proceedings of the research-to-practice conference at Ural Federal University named after Boris Yeltsin, Institute of Economics, Ural Branch of RAS]. 2014. Pp. 199-208. (In Russian).

18. Makarenko G.P. Ekologo-ekonomicheskaya otsenka vodookhrannoy roli lesa [Ecological-economic evaluation of water conservation role of forests]. *Formirovaniye lesnogo kadastra i sistema plat za lesopol'zovanie i arendy lesov Urala* [Formation of the forest inventory and the system of payments for forest use and lease of the forests of the Ural]. Yekaterinburg, 1996. Pp. 17-21. (In Russian).

19. Fomina V.F. Dostupnost' oplaty kommunal'nykh uslug v sel'skikh rayonakh respubliki Komi [Availability of payment for utility services in rural areas of the Komi Republic]. *Materialy IV Vserossiyskogo nauchnogo seminara "Aktual'nyye problemy, napravleniya i mekhanizmy razvitiya proizvoditel'nykh sil Severa – 2014"* [Materials of the 4th all-Russian scientific seminar "Current problems, trends and mechanisms of development of productive forces of the North in 2014"]. Syktyvkar, 2014. Pp. 144-154. (In Russian).

20. Kotko A.A. Vklyucheniye ekosistemnykh uslug v ekonomicheskiye otnosheniya [Inclusion of ecosystem services in economic relations]. *Izvestiya RAN. Seriya geograficheskaya* [Bulletin of RAS. Geographical series], 2009, no. 4, pp. 78-85. (In Russian).

21. Tsibul'nikova M.R. Uchet prirodnogo kapitala i ekosistemnykh uslug v upravlencheskikh resheniyakh [Taking into consideration natural capital and ecosystem services in management decisions]. *Vestnik TGU* [Bulletin of TSU], 2012, no. 360, pp.193-199. (In Russian).

22. Titova G.D. Platezhi za ekosistemnyye uslugi v programmakh ekokompensatsii [Payments for ecosystem services in environmental compensation programs]. *Astrakhanskiy Vestnik ekologicheskogo obrazovaniya* [Astrakhan herald of ecological education], 2015, no. 2 (32), pp. 105-110. (In Russian).

23. Tikhonova T.V. Otsenka effektivnosti napravleniy razvitiya osobo okhranyayemykh prirodnykh territoriy Respubliki Komi [Evaluation of the efficiency of development of specially protected natural areas in the Republic of Komi]. *Ekonomicheskiye i sotsial'nyye peremeny: fakty, tendentsii, prognoz* [Economic and social changes: facts, trends, forecast], 2015, no. 1 (37), pp. 182-195. (In Russian).

24. Bobylev S.N., Minakov V.S., Solov'yeva S.V., Tret'yakov V.V. *Ekologo-ekonomicheskiy indeks regionov RF* [Economic environmental index of Russian regions]. Moscow. Vsemirnyy fond dikoy prirody (WWF) i RIA Novosti. 2012. 152 p. (In Russian).

25. Motkin G.A. Ekonomicheskaya otsenka sredoobrazuyushchikh funktsiy ekosistem [Economic evaluation of environmental functions of ecosystems]. *Ekonomika i matematicheskiye metody* [Economics and mathematical methods], 2010, vol. 46, no. 1, pp. 3-11. (In Russian).

26. Motkin G.A. (Ed.). *Ekologicheskoye strakhovaniye v Leningradskoy oblasti: Sbornik yuridicheskikh i normativno-ekonomicheskikh dokumentov (proyekty)* [Environmental insurance in the Leningrad Oblast: a collection of legal and legal-economic documents (drafts)]. Moscow: Izdatel'stvo "Os'-89", 1999. 52 p. (In Russian).

27. *Razvitiye strakhovaniya v Respublike Bashkortostan* [Insurance development in the Republic of Bashkortostan]. Moscow, Ufa: PS "Granitsa", 2002. 39 p. (In Russian).

28. *Tsennost' lesov. Plata za ekosistemnyye uslugi v usloviyakh "zelenoy" ekonomiki. OON* [The value of forests. Payments for ecosystem services in a green economy]. Geneva, 2014. 94 p.

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