UDC 338.14: 502.335.(234.851)

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THE DAMAGE TO RESOURCES OF TRADITIONAL ENVIRONMENTAL MANAGEMENT AND ITS ECONOMIC ASSESSMENT

The Yamalsky district, which accounts for 20 % of the surface area in the Yamalo-Nenets Autonomous Okrug, is one of the main territories for traditional environmental management with reindeer husbandry and fishing as its principal economic sectors. These sectors are facing the most acute problems associated with intensive industrial and transport development of the tundra zone, degradation of pastures as a result of overgrazing following an uncontrolled increase in the livestock, and illegal fishing. Two anthropogenic factors have a negative impact on the soil and vegetation in the Yamalsky district—reindeer husbandry as the main traditional form of environmental management for Northern indigenous minorities and intensive man-made development of the territory (geological exploration, industrial activities, transport, construction). Since grazing is carried out across the entire territory of Yamal Peninsula that is not occupied by industrial zones, it is the largest form of environmental management and the leading factor of anthropogenic impact on Yamal's natural and territorial systems. The primary reason for the decline in fish resources is the disruption of their ecosystemic reproduction as a result of excessive catch caused primarily by illegal fishing. The scale of excessive catch associated with the growing population, including Northern indigenous minorities, and the density of road network to fishing grounds are increasing every year. This article proposes methodological approaches for assessing the economic losses caused by the damage to grazing resources and substantiates the amount of compensation to reimburse the losses arising from such damage by taking into account the decline in the productivity of land resources and the period required for restoration of economic and biological capacity of pastures for the corresponding years (compensation for economic losses). The assessment of economic losses of fish resources includes the decline of their economic value and, for a detailed calculation, it requires to use the adjusted population and biological approach. The authors provided examples of testing their methodological recommendations.

Keywords: Arctic territory, industrial development, natural and resource capacity, traditional economic sectors, reindeer husbandry, reindeer pastures, fishing, quota, Northern indigenous minorities, economic losses

Introduction

In recent years, Yamal Peninsula has become the most investment attractive region among the Arctic territories. Such close attention can be explained by the availability of large hydrocarbon reserves and the need to compensate for the decline of gas production in the old fields of Nadym-Pur-Tazovsky district of Yamalo-Nenets Autonomous Okrug by putting the new fields into operation.

In terms of the administration, the Yamal Peninsula belongs to the eponymous municipal district and represents the area of Yamalo-Nenets Autonomous Okrug with the most extreme natural and weather conditions. Yamalsky district is located in the Arctic Circle and is the second largest municipal entity of the Yamalo-Nenets Autonomous Okrug (148,000 km^2). The extreme natural environment is determined by its high latitude location with a cold long winter and a long-term snow cover (more than 260 days), short cool summer, a small amount of precipitation and frequent weather variability. A characteristic feature of the local climate is the active cyclonic activity, which is associated with strong winds and snowstorms (more than 100 days a year). The flat and low relief with the altitudes of up to 70 m accompanied by high waterlogging (17.0 %) and water content (lakes and rivers occupy 17.5 %) of the territory and the continuous distribution of permafrost make any drainage difficult. All this, along with low temperatures, causes the low capacity of soil and water to self-purification and the increased sensitivity of landscapes to natural and anthropogenic impacts. The ubiquitous tundra vegetation communities have high fodder value and are a natural base for the development of the reindeer husbandry. There are also wide opportunities for collecting wild plants, hunting, and fishing. All this in the aggregate constitutes a comprehensive system of traditional environmental management for local Northern indigenous minorities (NIM) with a year-round or seasonal use of renewable natural resources.

The accelerating process of industrial development led to the conflict between the man-made and traditional sectors of the economy in terms of using the natural resource capacity as manifested by the damage caused to reindeer pastures and river ecosystems, and direct and indirect economic losses in the leading traditional sectors of the economy. The extensive and seasonal nature of the activities in these sectors requires extensive areas and continuous reproduction of renewable resources for their productive activities, which leads to their constant intersection with the rapidly developing industrial sector. The increasing rates of population growth among the Northern indigenous minorities (NIM) led to additional problems in the development of traditional environmental management, which is exacerbating the above-mentioned conflict.

The State and Problems in the Development of Traditional Sectors

Reindeer Husbandry. According to statistical data, up until the mid-1960s, the number of reindeer in the district was slightly above 100 thousand (the maximum number was 142.9 in 1940, and the minimum number was 76.9 in 1950). This ensured the safety of reindeer pastures and their proper condition, which are especially valuable in the structure of land resources and account for about two-thirds of the territory of the municipal district. The number of livestock is increasing since the 1990s and sharply accelerated in the second half of 2000s. In 2010, the number of reindeer on the peninsula exceeded by more than 4 times the reindeer-feeding capacity of the territory determined as early as the 1960s in accordance with the pasture provision standard per reindeer in the tundra zone (Table 1).

In this respect, the most unfavorable situation with the provision of pasture resources due to excessive herd population is in the Yamalsky district. It accounts for 20 % of the pasture resources and 40 % of the reindeer population in the Yamalo-Nenets Autonomous Okrug. The growth of reindeer population, which led to overgrazing, is caused both by objective and subjective reasons.

The first objective reason is the increasing number of nomadic population, primarily Nenets people. A comparison of dynamics describing the growth of nomadic population and the number of reindeer reveals their correlation (Table 2).

Despite the considerable attention given to the regulation of livestock by the authorities of the Yamalo-Nenets Autonomous Okrug and Yamalsky Municipal District, the issues that would allow to reduce the livestock remain unresolved. On the contrary, with the exception of some years, in the Yamalsky district demonstrates the continuous increase in the total livestock (Table 3) both in households and public farms with some changes in the balance between these two forms of ownership.

The second objective reason that stimulates the growth of livestock is the industrial and transport development of Yamalsky district which, in the period from 2008 to 2015, led to a 2.8-fold increase in the number of working population, including a 3.7-fold increase in the basic and infrastructure industries (2.6- and 4-fold increase, respectively). It should be noted that this process is fueled by the influx of labor from other regions, while the number of the permanent population remains steady. As a result, the number of working population in the Yamalsky district exceeded the number of permanent residents by 1.7 times in 2015; and in 2016 (9 months) this figure was 2.2. At the same time, the local labor, which is largely represented by indigenous people, is employed primarily in traditional economic sectors and in the services. The increase in the number of temporary residents, on the one hand, expands the market for traditional products of the indigenous population (mostly venison and fish) through direct trade transactions with consumers among rotating shift workers. On the other hand, it creates social and environmental problems associated with the higher anthropogenic impact on the environment and increased demand for delicatessen fish, the stocks and catch quotas of which are limited.

There is also one more objective reason in the form of subsidies from the regional budget for the accumulation of “livestock capital”, which contribute not only to the preservation, but also to the increase in the livestock following the expansion of privately-owned herds. At the same time, this leads to the lower marketability of the sector. Unfortunately, the subsidies allocated by the state, Gazprom and the Okrug authorities are aimed primarily at establishing the conditions for increasing the reindeer population. In the total revenues of municipal reindeer husbandry farms, the financial support from all levels of the state budget accounts to more than 70 %. Moreover, the people engaged in a nomadic way of life are provided with social assistance in the amount of 2000 rubles; and those with a semi-nomadic way of life receive the social assistance in the amount of 600 rubles. In recent years, to reduce the excessive burden on pastures, the subsidies are allocated not only per head of reindeer livestock,

Table 1

The dynamics of reindeer population in the Yamalsky district

Year	Surface area, thousand ha	Reindeer-feeding capacity, headcount	Number of reindeer, headcount	Pasture area per reindeer, ha	Overabundance of reindeer, headcount
1933*	10300	160000	100000	103	no
1963	10294.0	77400	107500	96	30100
1990	9632.7	109365	177401	54	68036
2004	10601.6	109365	221329	48	111964
2010	10600.0	109365	290636	36.5	181271
2010**	9850.0	101631**	300000***	<26	278377

Calculations based on [1, p. 174; 2, p.3 7; 3], and also on the Collection of Federal Regulatory Legal Acts of the Yamalo-Nenets Autonomous Okrug in the Area of Guarantees for the Rights of Northern Indigenous Minorities (2nd ed., Salekhard, 2010. 288 p., p. 170, in Russian).

* Data of V.N. Andreev from [3, p. 235–249].

** Without the pastures degraded as a result of overgrazing and man-made impact.

*** Assessment.

Table 2

The dynamics of the number of nomadic population and the number of reindeer, and their specific indicators, livestock headcount/person/household

Year	Livestock, headcount	Number of households	Human population	Number of reindeer, headcount		Number of people per household
				per person	per household	
1987	151500	669	3456	44	226	5.1
1997	197077	911	5074	39	216	5.5
2001	205774	950	5111	40	216	5.4
2004	221320	964	5199	43	230	5.3
2006	191191	976	5278	36	196	5.4
2007	270889	971	5287	51	279	5.5
2008	276255	1004	5496	50	275	5.5
2010	290636	1031	5747	51	282	5.5
2012	277129	1048	5664	49	264	5.4
2014	293589	1175	5827	50	250	5.0
2015	234790	1210	5876	40	194	4.9
2016	254544	1207	5735	44	211	4.8

Calculation based on the data from Yamalstat and sources. (Doklad o sotsialno-ekonomicheskoy situatsii munitsipalnogo obrazovaniya Yamalskiy rayon za 2014 god. Yar-Sale, 2015. O rassmotrenii prognoza sotsialno-ekonomicheskogo razvitiya munitsipalnogo obrazovaniya Yamalskiy rayon na 2016–2018 gody [Report on the Socio-Economic Situation of the Municipal Entity Yamalsky District for 2014. Yar-Sale, 2015. Review of the Forecast of Socio-Economic Development of the Municipal Entity Yamalsky District for 2016–2018]. Retrieved from: https://docviewer.yandex.ru/?url=http%3A%2F%2Fmo-yamal.ru%2Fload_center%2FNB%2F2015 %2F3017.docx&name=3017.docx&lang=ru&c=5803af5e4b6f (date of access: 18.02.2017). (In Russ.); Doklad o sotsialno-ekonomicheskoy situatsii munitsipalnogo obrazovaniya Yamalskiy rayon za 2015 god [Report on the Socio-Economic Situation of the Municipal Entity Yamalsky District for 2015]. (2016). Yar-Sale, 103. (In Russ.))

Note: The decrease in specific indicators for 2015 is caused by a significant reduction in the total number of reindeer as a result of difficult environmental and weather conditions.

which automatically led to higher livestock, but also for venison at a rate of 110 rubles/kg while the purchase price is 180 rubles/kg (these subsidies account for 42 % in the total structure of subsidies) This stimulates higher meat production and, as a result, higher slaughter rate of animals and higher marketability of the sector. This is also facilitated by the policy of the Autonomous Okrug authorities to establish venison processing plants.

Currently, there are 3 venison processing facilities operating in the Yamalsky district. In the Okrug, the slaughter campaign lasts for three months (October through December). In 2013–2015, the plants were utilized at 78.9 % of their capacity, while the capacity of refrigeration equipment is 800 tons,

Table 3

The dynamics of the reindeer population in Yamalsky district, headcount as of January 1

Year	Total	Including:		Specific weight of households, %
		Agricultural enterprises	Households*	
1959	102200	71800	30400	29.7
1970	128729	79924	48805	37.9
1986	151500	84900	66600	44.0
1991	175321	78064	97257	55.5
1996	186930	67389	119541	63.9
2001	205774	61388	144386	70.2
2006	191191	81564	109627	57.3
2007	270889	95908	174981	64.6
2008	276255	135260	140995	51.0
2009	287052	156171	130881	45.6
2010	290636	164230	125867	43.3
2011	281596	165256	116340	41.3
2012	277129	164515	136786	40.6
2013	284157	168758	113619	40.6
2014	293589	184416	109173	37.2
2015	234790	152586	82204	35.0
2016	254544	159261	95283	37.5

Calculation based on data provided by Yamalstat.

* Together with peasant/farmer households and individual entrepreneurs.

which is 2.7 times less than the amount of produced meat. The main product of processing is meat, since the slaughter facilities have no specialized equipment required for preserving the skins, as well as extracting and storing such high value-added products as the endocrine and enzyme materials. However, these measures could not stop the growth of livestock.

The subjective reason for growing "livestock capital" is associated with the historically established mentality of Nenets people. They view the growth of reindeer population is the main indicator of their well-being. At the same time, the products of the sector are mostly used to meet the needs of reindeer farming families, and only a small part of them is sold on the market in order to buy the necessary industrial goods and food items. The mindset of the aboriginal population that emerged since the start of market reforms is skewed towards the development of reindeer husbandry, which led to the growth of reindeer population without taking into account the feed resources of the pastures. The environmental capacity, which constrains the growth of reindeer population, ceased to be a significant factor for the Nenets people. They do not want to acknowledge that, with a continuous growth of reindeer population, the pasture areas are gradually shrinking, and the remaining ones are experiencing the ever-increasing burden and degradation [4].

The historical experience of Komi-Zyryan people in the area of commercial reindeer husbandry described by A. A. Dunin-Gorkavich [5] in the end of 19th century, involving small herds (500 heads) and the annual slaughter of 20 % of the animals, which allowed to maintain the reproduction of reindeer at the same level, can hardly be used given the specific mentality of Nenets people.

The preservation and development of reindeer husbandry imply the high quality and development of such three equally important components as the pasture — reindeer — reindeer herder. The fundamental factors here are the preservation of the balance between the livestock and its feed base and timely reproduction of labor. Currently, the excessive reindeer population caused the degradation of pastures within the reviewed territory. The evidence of this can be found in the examples from global and Russian practice [6–14].

To this, we should also add the active industrial development and construction of infrastructure facilities, which is also associated with the withdrawal and disruption of reindeer pastures.

The total surface area of lands disrupted by man-made activities on the peninsula is about 200 thousand hectares[1], or less than 2 % of the total surface area of reindeer pastures in Yamal. So far, the impact remains on a pin-point and local scale. However, the withdrawal of some pastures puts a higher burden on neighboring territories as it leads to increased grazing on them and, thereby, accelerates their degradation. The construction of transport communications that cross the traditional migration routes of domesticated reindeer makes it more difficult to change pastures [15].

The land form legend of existing and planned gas industry facilities shows that the gas producers, first of all, develop the elevated, well-drained sections of tundra with a potential for building the transport network. For the same reasons, such places have long been developed by reindeer herders, and these areas often play a key role (calving pastures, approaches to river crossings) in the structure of land use. The problem of pasture withdrawal is exacerbated by the fact that the industrial development makes unusable not only the withdrawn area, but also the adjacent territory. "In most cases, the indirect environmental impact resulting from the construction of the industrial facility is more significant than the direct damage caused by its activities" [16, p. 124]. In addition, the expansion of industrial and transport development of the territory will lead to the increase of areas disturbed by man-made activities [4]. For example, in 2008–2015, the number of air-polluting sites increased from 8 to 28, while the number of stationary sources of air pollution reached 2471 sites; the emissions of pollutants increased from 1.7 to 33.25 thousand tons or by 19.6 times[2].

As we can see, the reindeer husbandry as the main traditional form of environmental management employed by NIM and intensive industrial and transport development of the Yamalsky district are the primary anthropogenic factors that have a negative impact on the ecosystems of the peninsula. All this requires to establish the appropriate institutional conditions in order to ensure a compromise in the development of traditional and man-made economic sectors [17].

Since grazing is carried out across the entire territory of Yamal Peninsula that is not occupied by industrial zones, it is the largest form of environmental management and the leading factor of anthropogenic impact on Yamal's natural and territorial systems. Today, the losses of pasture areas as a result of the excessive burden put on them by reindeer population and increasing deflationary processes exceed the losses of pastures caused by the industrial development of the peninsula by a factor of at least 3. The irretrievable losses of grazing lands following the formation of sandy outcrops exceed by more than 20 times similar losses from the development of Bovanenkovskoye oil and gas condensate field. In addition, the high burden put on pastures led to the reduction in green fodder stocks on the area of several million hectares. The restoration of these disrupted pastures will take several decades. Such is the price of keeping a high reindeer population [4]. The current burden on pastures is extremely high and dangerous for the tundra zone, and the reindeer grazing already plays the role of a large-scale destabilizing factor in natural and territorial systems. The degradation affects even the pastures that have not been touched yet by the industrial development.

Fishery. The fishery is a priority area of traditional environmental management both in Yamalo-Nenets Autonomous Okrug and Yamalsky district. In the first year after the establishment of the district (1931), 5.7 thousand tons of fish were produced in its river basins and lakes; in 1940, this figure was 10 thousand tons; in 1950, 8.5 thousand tons; and in 1960, the catch reached a record level of 17.4 thousand tons following the expansion of commercial development of the area and increased intensity of fishing. By the late 1960s, the spawning populations have significantly declined [18, p. 148–150]. This led to the ban on trawl fishing in the Gulf of Ob, and the bulk of the fish catch shifted to the flood plain of the Ob river. By the end of the 1970s, the whitefish population began to recover, and in the 1980s the total catch of whitefish increased. However, since the mid-1990s, it began to fall following the decline of fish resources and the introduction of corresponding catch quotas, including for NIM. Along with the decline in fish stocks, there was the reduction of quotas on harvesting the aquatic biological resources for industrial fishing (Table 4).

We also observe a trend toward the reduction of quotas of valuable fish species for Northern indigenous minorities (NIM) (Table 5).

[1] According to statistical data provided in 22–2 land plot legend forms (2013), the surface area of disrupted lands is 10.2 thousand hectares, including 6.3 thousand hectares of agricultural land. But, in addition to that, 250.1 thousand hectares account for sand areas, a significant part of which emerged following the degradation of reindeer pastures.

[2] Ob ekologicheskoy situatsii v Yamalo-Nenetskom avtonomnom okruge v 2015 godu. Doklad [On the Environmental Situation in the Yamalo-Nenets Autonomous Okrug in 2015. Report]. (2016). Salekhard, 38. (In Russ).

Table 4

The dynamics of industrial quotas for fishing, tons

Year	Fish species						
	Nelma	Broad whitefish	Humpback whitefish	Arctic cisco	Peled	Tugun	Total
2010	195.79	561.78	1117.35	214.03	1694.35	0.965	4107.560
2012	229.36	253.39	657.14	99.74	1264.69	0.97	5138.745
2015	9.458	236.155	612.926	97.740	831.539	2.075	1789.893
2016	—	253.72	680.802	92.869	1022.399	2.775	2052.565

Notes: 2010 quotas also include sterlet (0.95 tons), muksun (312.37 tons, in rivers), Arctic char (9.98 tons, in lakes); 2012 quotas also include sterlet (0.99 tons), Arctic char (0.92 tons), muksun (194.3 tons, in rivers), Arctic char (7.98 tons, in lakes).

Calculation based on data from the Report on the State of Environment in the Yamalo-Nenets Autonomous Okrug in 2010. Salekhard, 2011. p. 133–134; Report on the State of Environment in the Yamalo-Nenets Autonomous Okrug in 2012. Salekhard, 2013. p. 117–119; Annexes 1 and 2 to the Orders on Quotas in YaNAO No. 1542 of 23.12.2014 and No. 896 of 16.12.2015.

Table 5

The dynamics of quotas granted for traditional fishing, tons

Year	Fish species						
	Muksun	Nelma	Broad whitefish	Humpback whitefish	Peled	Arctic cisco	Total
2009	6	5	20	30	30	3	94
2010	16	15	20	30	30	10	121
2011	16	25	20	30	30	10	131
2012	16	25	20	30	30	10	131
2013	16	25	20	30	30	10	131
2015	-	27	21	31	28	12	119

In the Yamalsky district, where resides about a third of NIM in the Yamalo-Nenets Autonomous Okrug, the quotas for the whitefish amounted to 65.1 tons; and together with vendace 538.1 tons, or 23.7 kg/person a year, which is below their average annual per capita consumption of fish products.

However, neither the reduction of quotas, nor bans imposed on catch, nor penalties led to the increase of valuable fish population in the natural water basins. Its share in the total catch is steadily falling, and the share of the so-called "black fish" is increasing year by year. Most researchers believe (and these views are shared by the authors) that the root cause of the decline in fish resources is the disruption in ecosystem reproduction of fish resources as a result of their excessive catch ([19–20] and others). In turn, one of the reasons for the excessive catch is illegal fishing, the scale of which associated with the growing population, including among Northern indigenous minorities, and the density of road network to fishing grounds are increasing every year. Moreover, the primary goal of poachers is to catch valuable species of whitefish. The whitefish population is exposed not only to direct but also the indirect impact of industrial fishing, which leads to undesirable effects. In particular, there is a negative impact of individual fishing gear, such as small-meshed nets, on the situation of whitefish spawners during their migration and mass breeding. Also, we should not discount the possible contamination of spawning water basins in the Lower Ob river. Unlike the Middle Ob river, where the pollution represents a substantial reason for declining catches, here all damage is still recoverable.

The study of reasons for illegal fishing led to the analysis of information on the number of population in the Autonomous Okrug. According to statistics, there is a rapid growth in the permanent population of the Yamalo-Nenets Autonomous Okrug from 62.3 thousand people in 1959 to 494.8 thousand people in 1989 and up to 540 thousand people in 2015, or by 8.7 times. With the annual rate of fish consumption established at 18.6 kg per capita, meeting the needs of the population in the Yamalo-Nenets Autonomous Okrug requires 10,000 tons of fish, which is more than the average annual catches of recent years. Over the same period, NIM population, one of the primary consumers of fish products (average per capita demand is 40 kg), has almost tripled. Even among nomadic Nenets people, the fish forms the basis of their diet [21]. At the same time, the fishing quotas, especially for whitefish,

granted to NIM are reduced year after year. In these circumstances, the illegal fishing becomes a way of subsistence. This is evidenced by the results of a large-scale survey conducted in the Russian Far East on the subject of poaching and illegal fishing. According to the survey, 38.5 % of respondents consider poverty as the main reason for poaching [22]. According to the Federal State Statistics Service[3], 20 % of poachers has the income below the subsistence minimum; this figure is even higher among NIM, as their per capita gross income per household in 2009 was 84 % of the subsistence minimum). This means that, in fact, the Northern indigenous minorities are also engaged in illegal fishing when they catch the excessive quantities of valuable whitefish and ignore the restrictions on fishing in the Gulf of Ob, Taz Estuary, Khalmyer Bay, Baydaratskaya Bay, and Yuratski Bay [24].

A major threat to the reproduction of fish resources in the Lower Ob river is posed by the development of the Tambeyskoye, Krusensternovskoye and Novoportovskoye fields. The experience of developing the Bovanenkovo field shows that this is accompanied by uncontrolled catching of whitefish by the workers of industrial facilities and poachers. If the events unfold under the same scenario as in the Bovanenkovo gas condensate field, the whitefish populations can be brought to extinction. A similar threat is posed by the construction of Sabetta port [24], the approach to the terminal of which requires a deep channel of about 4 km long. Its deepening can cause considerable damage to the feed base following the decrease in the ichthyomass and the whitefish populations in the places of their wintering. There is also another threat associated with the exploitation of oil and gas resources in the Cape Kamenny area. It is quite possible that the pollution makes an impact on the ichthyofauna of the basin, which will result not only in the decline of the fish population, but also in the decrease of their weight, which also affects the amount of the catch [25, p. 3–12]. A particular danger for fish is posed by emergency oil spills that pollute large areas in short periods of time. After the spill of only 1 ton of oil, the area of pollution is 20–30 km [26].

Today, the environmental effect caused by systematic excessive catch of the whitefish is the impossibility to naturally restore the population. According to the experts, this requires the artificial reproduction, such as the release of young muksun in the amount of 0.5 billion annually, in addition to the fry of other whitefish species. It is assumed that the fish breeding plant, which is being built in the settlement of Kharp (Priuralsky district of the Yamalo-Nenets Autonomous Okrug) and expected to start operating by the end of 2016, will produce 110 million fry, including 60 million fry of peled, 20 million fry of muksun, and 20 million fry of broad whitefish. This will improve the situation with the reproduction of whitefish but will not completely address the problem.

The economic assessment of damage caused to resources of traditional environmental management can be provided with the methodological recommendations proposed by the authors.

Methodological Recommendations for Assessing the Economic Losses Caused by the Damage to Resources of Traditional Environmental Management

According to the proposed methodological approach[4], the assessments of economic losses caused by the damage to reindeer pastures, and the amount of losses should be established in the land management documentation (land management plan or land management file) following the deterioration in the quality of pasture lands (degradation at 4 degrees of impact) after special surveys conducted at the initiative of state authorities and local self-government authorities.

There are several degrees in the disruption of pastures in the case of their overgrazing:

— Weak: the mechanical disruption of vegetation cover and soils does not exceed 10 % of the pasture area; reindeer-feeding capacity of pastures exceeded by up to 1.1 times (Coefficient of exceeding reindeer-feeding capacity ≤1.1);

[3] Calculations based on: Osnovnye pokazateli byudzhetov domashnikh khozyaystv v rayonakh prozhivaniya korennykh malochislennykh narodov Severa [Main Indicators of Household Budgets in the Areas of Northern Indigenous Minorities]. Ekonomicheskie i sotsialnyне pokazateli rayonov prozhivaniya korennykh malochislennykh narodov Severa. 2010 god [Economic and Social Indicators of the Areas of Northern Indigenous Minorities. 2010]. Retrieved from:http://www.gks.ru/bgd/regl/b10_23/Main.htm (date of access: 24.03.2017). (In Russ.)

[4] On the approval of methodology for calculating the amount of losses caused to associations of indigenous minorities of the North, Siberia and the Far East of the Russian Federation as a result of economic and other activities of organizations of all forms of ownership and individuals in places of traditional residence and traditional economic activities of indigenous minorities of the Russian Federation. The Order of the Ministry of Regional Development of the Russian Federation No. 565 of 09.12.2009 (In Russ).

— Moderate: the mechanical disruption of vegetation cover and soils does not exceed 11–25 % of the pasture area; daily ration of reindeer grazing is disrupted; reindeer-feeding capacity of pastures exceeded by 1.4 times or more (Coefficient of exceeding reindeer-feeding capacity = 1.4–1.8);

— Average: the mechanical disruption of vegetation cover and soils does not exceed 26–45 % of the pasture area; daily ration of reindeer grazing is disrupted; reindeer-feeding capacity of pastures exceeded by 1.8 times or more (Coefficient of exceeding reindeer-feeding capacity = 1.8–2.2);

— Strong: the mechanical disruption of vegetation cover and soils does not exceed 46–70 % of the pasture area; daily ration of reindeer grazing is disrupted; reindeer-feeding capacity of pastures exceeded by 2.2 times or more (Coefficient of exceeding reindeer-feeding capacity = 2.2–2.9);

— Catastrophic: the mechanical disruption of vegetation cover and soils exceeds 70 % of the pasture area; reindeer-feeding capacity of pastures exceeded by 3 times or more (Coefficient of exceeding reindeer-feeding capacity ≥3).

The scientifically proved annual reindeer-feeding capacity of 1 hectare of pastures (annual economic and biological capacity) for the Yamalo-Nenets Autonomous Okrug is 0.014–0.033 reindeer/year/ha (0.023 on average) [27].

The period for restoration of disrupted economic and biological capacity is as follows: with weak impact, it is 1–5 years; with moderate impact, it is 6–10 years; with strong impact, it is up to 25 years; with catastrophic impact, the disrupted economic and biological capacity cannot be restored (currently, 583 thousand hectares of pastures are irrecoverably lost).

The methodological approach to establishing the economic losses caused by the degradation of land implies their assessment by taking into account the lost profits. The losses arising from soil degradation are made of lost profits, the amount of which is determined on the basis of the gross annual income [28] generated by the land users from 1 hectare of land, and losses of wild crops. Unlike the common approach, the approach proposed by the authors requires to determine the economic losses by using the statistics for 4–5 years in order to make a balanced assessment of the impact made by the climate and corresponding change in the value of the reindeer-feeding capacity.

Estimated annual gross income (Income) is defined as the difference between the value of the gross output of traditional economic sectors and material and technical costs of their management.

$$Losses = [(Income \times Sp \times Standard)/Coefficient\ of\ exceeding - (Income \times Sp \times Standard)]T + \\ + [(WildCrops \times Coefficient\ of\ coverage \times Coefficient\ of\ harvesting \times Coefficient\ of\ disruption) - \\ - (WildCrops \times Coefficient\ of\ coverage \times Coefficient\ of\ harvesting)]\ T, \text{ rubles/ha}, \quad (1)$$

Where "*Income*" is the average annual gross income from reindeer husbandry products, rubles/reindeer; "*Sp*" is the surface area of pastures, ha; "*Standard*" is the standard reindeer-feeding capacity of pastures, reindeer/ha; "*Coefficient of exceeding*" is the coefficient of exceeding the reindeer-feeding capacity of pastures; "*WildCrops*" is the average annual gross income from the harvesting and selling wild crops, rubles/ha; "*Coefficient of coverage*" is the coefficient of projected coverage area; "*Coefficient of harvesting*" is the coefficient of harvesting area; "*Coefficient of disruption*" is the coefficient of disruption of land; "*T*" is the time of restoration, years.

A model example of calculating the economic losses following the disruption of the standard reindeer-feeding capacity of pastures. The farm (private, public) exceeded the scientifically proved reindeer-feeding capacity of pastures (*Coefficient of exceeding* = 1.5). The survey found a moderate disruption of the soil coverage on the surface area of 100 hectares with a restoration period of 6 years, during which the disrupted sections of the pasture are not used. The average annual gross income is assumed to be at a rate of 25 % of the value of reindeer products by taking into account all parts of the reindeer [29]:

$$14600 \text{ rubles} \times 0.25 = 3650 \text{ rubles/reindeer}.$$

Based on the example of shrub-moss-lichen tundra, the income from harvesting and selling wild crops during the work [30] is estimated at 4600 rubles/ ha (52 % of product cost); coefficient of projected coverage area is 0.25; coefficient of harvesting area is 0.12; coefficient of disruption of land is 0.26.

$$Losses = [(3650 \times 100 \times 0.023)/1.5 - (3650 \times 100 \times 0.023)] \times 6 + [(4600 \times \\ \times 0.25 \times 0.12 \times 100 \times 0.26) - (4600 \times 0.25 \times 0.12 \times 100)] \times 6 = -78061.8 \text{ rubles}$$

The depletion of fish resources and reduction of their economic value generate economic losses both for enterprises engaged in the production and processing of fish resources, and for NIM. The aggregated estimation of economic losses (*Ae*) requires to assess the value of ith fish species.

$$Ae = [\sum_{i=1}^{n}(Pricei - Costsi)\times(Catchi1\times Share1)] - \sum_{i=1}^{n}[(Pricei - Costsi)\times(Catchi2\times Share2)], \quad (2)$$

Where "*Pricei*" is the price of the ith fish species, rubles/kg; "*Costsi*" are the costs of production of the ith fish species, rubles/kg; "*Catchi*1" is the catch of the ith fish species in the estimated year including quotas, kg; "*Catchi*2" is the catch of the ith fish species in the compared period, kg[5]; "*Share*1" is the share of valuable fish species in the catch of the estimated year, unit fraction; "*Share*2" is the average share of valuable fish species in the compared period, unit fraction.

A model example of calculating the economic losses from illegal fishing based on the value of fish species. The catch is made in closed natural water basins and river systems. The average catch quota is 0.2 units and is included in the total catch (information of the Fishery Council of the Yamalo-Nenets Autonomous Okrug). The quota is allocated by fish species and by fishing enterprises. The structure by species and the dynamics of the catch for 11 years are provided in Table 6.

Table 6

The dynamics of the catch of aquatic biological resources of Yamalo-Nenets Autonomous Okrug for 2005–2016, tons

Indicator	2005	2006	2007	2008	2009	2011	2012	2013	2014	2015	2016
Catch	7700	7700	6500	8400	8900	8649	8399	8013	8146	8090	9892
Including whitefish	5000	4400	3500	4300	4000	4329	3822	3997	4079	3424	3660
Specific weight, %	64.9	57.1	53.8	51.2	44.9	50.1	45.5	49.9	50.1	42.3	37.0

Calculation based on data from Report on the Environmental Situation in the Yamalo-Nenets Autonomous Okrug in 2015. Salekhard, 2016. p. 90.

The average price of fish products made of valuable species is 530 rubles per kg; common species, 80 rubles per kg. The production cost of fish products made of valuable species is 230 rubles/kg; common species, 63 rubles/kg. The average catch of the ith species of fish resources and the average share of valuable fish species in the compared period (10 years, from 2005 to 2015) are calculated on the basis of data from Table 7:

$$\text{Ae} = [(530-230)\times(9892000\times 0.37) + (80-63)\times(9892000\times 0.63)] - [(530-230)\times 8049680\times 0.51) + \\ + (80-63)\times(8049680\times 0.49)] = -113654000 \text{ rubles}$$

Although the annual catch increased in 2016 compared to the period of 2005–2015, but the cost of fish resources has declined. The key reason underlying the change in the structure is the irrational fishing of valuable species, primarily as a result of illegal fishing. The changes occurred amid a relatively weak specific man-made impact on water ecosystems in the area of the Gulf of Ob [31], i. e., only due to illegal fishing.

The annual losses are caused by the current level of illegal fish catch and the number of caught females of reproductive age, when we take into account the maximum age when they stop spawning and the average age of catch in illegal fishing. In this case, we need to consider the average number of spawned female eggs, their survival coefficient, and the survival rate of fry. The difference between the maximum age of females and the average age of their catch in illegal fishing allows to determine the number of non-produced offspring and corresponding lost profit for this period. The economic losses are also generated by the entire current level of illegal fishing.

In this case, the annual economic losses (*A-annual*) can be determined as follows:

$$A - annual = \sum_{i=1}^{n}[(Ni - Nmi - Nnsi)\times Ksfi\times Kesi\times Kfsi\times Ei\times Cifi + (Ni\times Cifi)]\times Pi, \quad (3)$$

[5] The periodicity is caused by changes in the abundance and biomass of fish populations over time. For the catches of whitefish, the period is 9–11 years (assumed to be 10 years).

Where "*Ni*" is the number of the ith fish species in the catch, units; "*N-non-spawningi*" is the number of non-spawning females of the ith fish species, units; "*Nmi*" is the number of males; "*Coefficient-spawning-femalesi*" is the share of females of spawning age; "*Coefficient-egg-survivali*" is the coefficient of egg survival for the ith fish species; "*Coefficient-fry-survivali*" is the coefficient of fry survival for the ith fish species; "*Eggsi*" is the number of eggs per breeding cycle in females of the ith species; "*Coefficient-illegal-fishingi*" is the share of the ith fish species caught illegally; "*Pi*" is the average price of the ith fish species, rubles/unit.

A model example of calculating the annual economic losses from illegal fishing of valuable species. A number of caught fish is 53000, including 26500 males; the share of spawning age females is 0.7; the number of non-spawning females is 2650. The number of eggs fertilized in a breeding cycle is 40000; the survival rate of eggs is 0.01 %; the survival rate of fry is 0.01 %. The share of fish caught by illegal fishers is 0.3; the price of one fish is 1200 rubles.

$$Losses = [(53000 - 26500 - 2650) \times 0.7 \times 0{,}01 \times 0.01 \times 40000 + (26500 + 2650] \times 0.3 \times 1200 =$$
$$= 34\ 534\ 800\ 000 \text{ rubles}$$

Total economic losses (Losses) including wasted offspring:

$$\text{Losses} = \sum_{i=1}^{n} [(Ni - Nmi - Nnsi) \times Ksfi \times Kesi \times Kfsi \times Ei \times Cifi \times (Age\max i - Aifi) + (Ni \times Cifi) \times (Age\max i - Aifi)] \times Pi, \quad (4)$$

Where "*Agemaxi*"; "*Age-illegal-fishingi*" is the maximum age of reproduction and average age of fish caught in illegal fishing of the ith fish species, years old; in case of *Age-illegal-fishingi* ≥ *Agemini.*

A model example of calculating general economic losses from the illegal fishing of valuable fish species. The number of caught fish is 53000 units, including 26500 males; the share of spawning age females is 0.7; the number of non-spawning females is 2650. The maximum spawning age of fish is 14 years old; the minimum spawning age is 7 years old; the average age of fish caught in illegal fishing is 7 years old. The number of eggs fertilized in a breeding cycle is 40000; the survival rate of eggs is 0.01 %; the survival rate of fry is 0.01 %. The share of fish caught by illegal fishers is 0.3; the price of one fish is 1200 rubles.

$$Losses = [(53000 - 2650 - 26500) \times 0.7 \times (14 - 7) \times 0.01 \times 0.01 \times 40000 + (2650 + 26500] \times 0.3 \times 1200 =$$
$$= 178\ 779\ 600\ 000 \text{ rubles.}$$

Conclusion

The consequences of the negative anthropogenic impact caused by reindeer overgrazing and excessive catch of valuable fish species represent irrecoverable socio-economic and environmental losses of renewable natural resources. The following measures are required to address this problem.

To gradually reduce the number of reindeer livestock, we propose to:

— Introduce legal restrictions on the growth of livestock;

— Increase the procurement prices for venison;

— Ensure conditions for deep and non-waste processing of products and raw materials;

— Introduce compensation for losses caused by damage to reindeer pastures that takes into account the decline in the productivity of land and period required for restoration of the economic and biological capacity of pastures for the corresponding years (compensation for economic losses determined with the recommended methodological tools).

The following is required in order to prevent or at least reduce the illegal fishing:

— Introducing a special set of measures, primarily of legal nature, to exclude the illegal fishing by the personnel of mining companies, including the use of close-meshed nets in inland water basins, which is primarily associated with the development of new mineral deposit fields;

— Ensuring a more thorough elaboration of the Environmental Impact Assessment (EIA) for the construction of the port of Sabetta and professional environmental expert review based on a comprehensive approach to environmental management in the coastal zone.

— Expanding the artificial reproduction of fish stocks in order to maintain the fish stocks while addressing the problem of illegal fishing.

— Using the proposed methodological toolkit for the economic assessment of the effects caused to fish resources by industrial and transport development of the territory and establishing the effectiveness of measures aimed at reducing the illegal fishing and substantiating a number of penalties.

Acknowledgements

The article has been supported by the project №15–14–7-13 "Scenario Approaches to the Implementation of the Ural Vector in the Exploration and Development of the Russian Arctic Amid the Global Instability."

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