ISSN 2079-0961, Arid Ecosystems, 2022, Vol. 12, No. 4, pp. 455–461. © Pleiades Publishing, Ltd., 2022.
Russian Text © The Author(s), 2022, published in Aridnye Ekosistemy, 2022, Vol. 28, No. 3(92), pp. 131–139.

INDUSTRIAL PROBLEMS OF THE STUDY OF ARID TERRITORIES

Environmental and Economic Assessment of Agricultural Land Degradation in the Central and Western Zones of the Republic of Tyva

A. D. Sambuu[a], *, A. O. Oksyulyuk[a], and A. Yu. Kaldar-ool[a]

[a] *Tuva Institute of Complex Development of Natural Resources, Siberian Branch, Russian Academy of Sciences, Kyzyl, 667007 Russia*

**e-mail: sambuu@mail.ru*

Received January 26, 2022; revised June 30, 2022; accepted July 1, 2022

Abstract—The presented ecological and economic assessment of agricultural land in the Republic of Tyva was developed taking into account the theoretical foundations of the economic assessment of the cost of land and the methods for valuation of environmentally significant factors. According to the agricultural and natural-economic zoning of the East Siberian region, the Republic of Tyva is assigned to the steppe sheep-breeding and cattle-breeding zone. For the purpose of a more rational distribution and scientifically based specialization of agricultural production, the territory of Tuva is divided into four agricultural zones (Economics of the Tuva ASSR, 1973). The agricultural lands of the study area are included in the Central agricultural zone, mainly agricultural subtaiga, livestock-grain steppe and in the mainly livestock-grain Western agricultural zone. These are the largest, developed and densely populated parts of the republic, where most of the arable land, two-thirds of the hayfields and pastures, and more than 80% of the population of the republic are concentrated. Territories of agricultural lands are located within the dry-steppe, steppe and forest-steppe natural and climatic zones. The climate is characterized by the highest degree of aridity. The main types of soils on arable land are chestnut sandy loamy soils that are subject to wind erosion (60%), chernozems (23%), and alluvial soddy soils (15%). The performed assessment shows that the total damage from soil degradation for the Central and Western agricultural zones of the republic is estimated at more than 3.5 bln rubles, which is about one-third of the cost of agricultural land of the republic. A decrease in the cost of land for the period from 2012 to 2017 was revealed for the Tandinskii (54.1%) and Chedi-Kholskii districts (47.2%), which is due to soil degradation.

Keywords: environmental and economic assessment, soil degradation, agricultural zone, basin, Tyva Republic

DOI: 10.1134/S2079096122040199

INTRODUCTION

Ecological and economic assessment of land degradation is a new developing area at the intersection of natural and economic sciences. Land degradation is a global problem that leads to consequences such as the decline in the gross domestic product of countries, the deterioration of the economic situation of the local population, the decline in food security, climate change, and loss of biodiversity (Lee et al., 2014). Fundamental studies of land degradation in Russia are the subject of many works by employees of the V.V. Dokuchaev Soil Institute (Sobolev, 1948, 1970; Bazilevich and Pankova, 1967; *Nauchnye osnovy* ..., 2013; Karmanov and Bulgakov, 2012; Yakovlev et al., 2016). Research on the development of methods for the environmental and economic valuation of land in the country has been carried out for more than 20 years, and at present there are more than 10 methods of land valuation within the framework of three approaches adopted in international practice: comparative, cost and profit approaches (*Otsenka* ..., 1999; Kust, 2020). The basis for economic methods of land management is the cadastral value, which is determined in the course of the state cadastral valuation of agricultural land by capitalizing the estimated rental income. Depending on the impact of various types of environmental factors in Russia, there are various methods for assessing damage. To make the ecological and economic assessment of the degradation of agricultural lands in the republic, we used the "Metodika opredeleniya razmerov ushcherba ot degradatsii pochv i zemel'" (1994).

The goal of this study was an ecological and economic assessment of agricultural lands in the Central and Western agricultural zones of the Republic of Tyva, taking into account their degradation and environmental damage.

MATERIALS AND METHODS

Tuva is a mountainous country with altitude fluctuations from 520 to 3970 m a.s.l. BS, as a result of which there is a large landscape heterogeneity of the

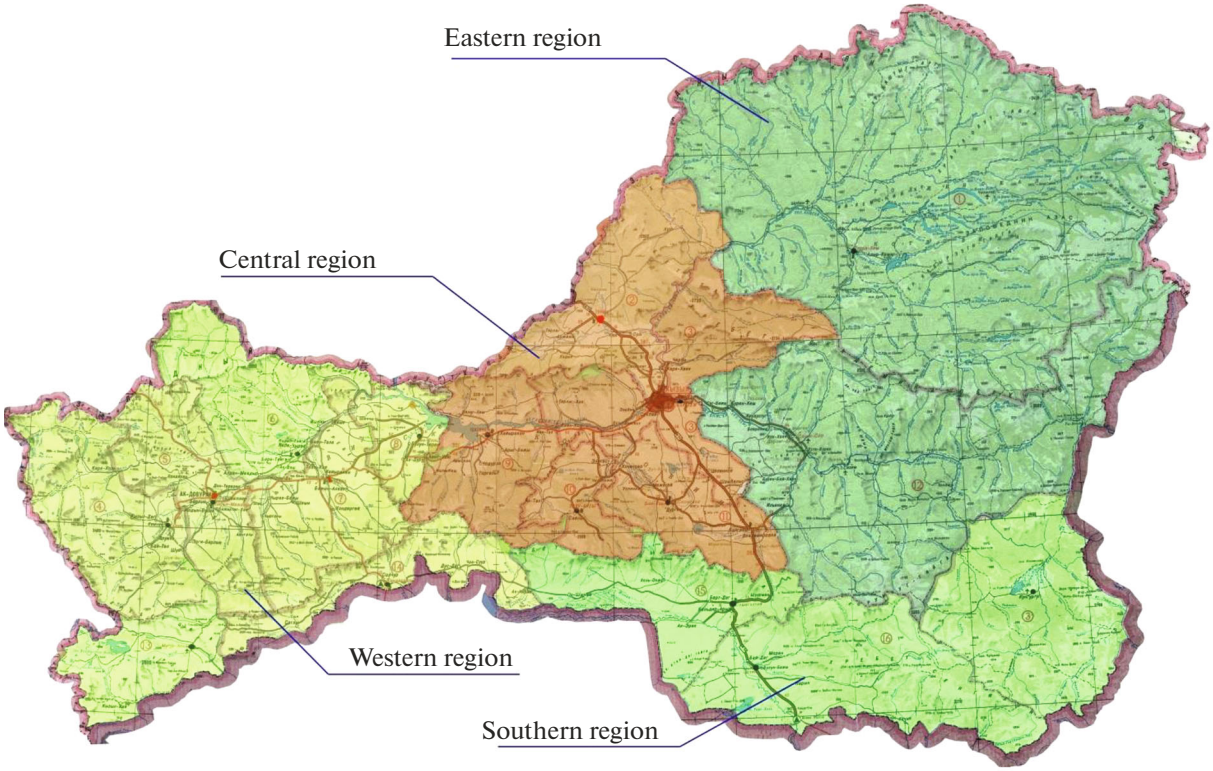

Fig. 1. The scheme of agricultural zoning of the territory of Tuva.

territory. According to the predominance of certain landscapes, the territory of Tuva belongs to two latitudinal geographical zones of Eurasia: taiga-forest and steppe zones (Nosin, 1963). The manifestation of latitudinal zonality is expressed in intermountain basins located at approximately the same hypsometric levels. Due to the same zonal-climatic reasons, various series of vertical natural zones are created on the mountains.

The object of the study is the agricultural land of the Republic of Tyva. According to the grouping of regions and farms of Tuva by similar natural and economic conditions (Soldatov, 1967), the studied areas of agricultural land are included in the Central zone, mainly agricultural subtaiga, livestock-grain steppe, as well as mainly livestock-grain Western zone (Fig. 1). The zones are located mainly in the Central Tuva Basin that is the most extensive of the intermountain basins of Tuva with a predominance of plain, hilly, low-mountain relief elements, including low foothills along the edges of the basin. Territories of agricultural lands are located within the dry-steppe, steppe and forest-steppe natural and climatic zones. The climate is characterized by the highest degree of contrast: winters with little snow, hot and dry summers, and a large amplitude of absolute and daily temperatures are characteristic features of the climate of the basin (*Agroklimaticheskie resursy* ..., 1974; Table 1).

The soils of the intermountain basins of Tuva belong to the steppe zone of the sub-boreal belt of Eurasia with predominantly steppe and desert-steppe soil formation groups predominating (Nosin, 1963). The main types of soils on arable lands of the Central Tuva Basin are chestnut sandy loam soils that are subject to wind erosion (60%), chernozems (23%), and alluvial soddy soils (15%).

The land fund of the Republic of Tuva as of January 1, 2021 is 16860.4 thou ha, the total area of agricultural land is 3363.9 thou ha (19.9% of the total area of the land fund of the republic). Of these, 2653.6 thou ha (78.9%) are agricultural land, 710.2 thou ha (21.1%) are non-agricultural land. As part of agricultural land, the area of arable land is 135.5 thou ha, the area of fallow land is 61.4 thou ha, the area of hayfields is 54.8 thou ha, and the area of pastures is 2401.9 thou ha (*Statisticheskii* ..., 2021).

After reforming the country's agriculture in 1991, the transfer of agricultural land to self-sufficiency in Tuva led to the exclusion from circulation of 284.6 thou ha of arable land. The transition from a planned economy to a market economy led to a sharp decrease in the area of agricultural land. Thus, from 1990 to 2020, the area of agricultural land decreased from 3.9 mln ha to 2.6 mln ha (*Kozhuuny i goroda* ..., 2016; *Gosudarstvennyi doklad* ..., 2021). The reduction in the area of arable land is due to the increase in fal-

Table 1. Meteorological and agrochemical assessment of the Central Tuva Basin

Indicator	Dry-steppe zone	Steppe zone	Forest-steppe zone
Altitude above sea level, m	600–800	500–900	900–1100
Sum of effective temperatures above 10°C	2158	1795	1725
Annual amount of precipitation, mm	150–220	200–250	300–350
Hydrothermal coefficient (HTC)	0.7	1.0	1.3
Reserves of productive moisture in the 0–100 cm layer by the beginning of vegetation, mm	26	33	45
Number of dry wind days	52	43	27
Duration of the frost-free period, days	100–120	100–110	90–100

low lands and partially the transfer of arable land to the lands of the state land reserve (Belek et al., 2017). At present, pastures predominate among all types of agricultural land (Fig. 2).

Ecological and economic assessments of agricultural lands were made for a number of regions of the country (Makarov et al., 2016, 2017a, 2017b, 2018, 2019, 2020; Yakovlev et al., 2016; Bondarenko, 2016; Badmaev, 2016; Tsvetnov et al., 2019; Makarov et al., 2021). For the Republic of Tyva, such an assessment has been carried out by us for the first time (Dabiev and Sambuu, 2020). The assessment of soil degradation of agricultural lands of districts (kozhuuns) of two zones of the republic (Fig. 3) was carried out according to the "Methodology for Determining the Amount of Damage from Soil and Land Degradation" (1994). The methodology is available in the use of calculated data: binding to the cadastral and economic assessment of agricultural land, the use of environmental coefficients, which depend both on the ecological situation in the territories and the degree of change in soil degradation. The source of information is literary data, regional reports on the state and use of land, statistical data (*Kozhuuny i goroda* ..., 2016; *Doklad o sostoyanii* ..., 2020; *Gosudarstvennyi doklad* ..., 2021; *Sotsial'no-ekonomicheskie pokazateli* ..., 2019; *Statisticheskii ezhegodnik* ..., 2019, 2020, 2021; *Statisticheskii sbornik* ..., 2021).

The following formula is used for assessment (*Methodika*..., 1994):

$$Ad = Cs \times S \times Ce \times Cd \times Ci + Ai \times S \times Cr,$$

where Ad is the amount of damage from soil and land degradation (thou rubles); Cs is the cost standard (cadastral or market value); Ai is the annual income per unit area (thou rubles); S is the area of degraded soils and lands (ha); Ce is the coefficient of the ecological situation of the territory; Cr is the conversion factor depending on the period of time for the recovery of degraded soils and lands; Cd is the conversion factor depending on the change in the degree of soil and land degradation; and Ci is the coefficient for specially protected areas.

In the case of degradation of soils and lands within specially protected areas, regional authorities may introduce increasing coefficients (Ci) for the cost standards: 3.0 for the lands of the natural reserve fund, 2.0 for the lands of nature protection, recreational, and historical and cultural purposes, 1.5 for the lands of recreational purposes, 1.0 for other lands (*Metodika opredeleniya* ..., 1994). To assess the environmental damage to agricultural lands, we used the coefficient of the ecological situation and the significance of the state of soils of 1.1 and the coefficient of recovery of soils and lands of 0.9 (*Metodika opredeleniya* ..., 1994; *Postanovlenie pravitel'stva RF* ..., 2014).

RESULTS AND DISCUSSION

The central and western agricultural zones of Tuva are the largest, developed and densely populated parts of the republic, where 63% of arable land and two-thirds of the hayfields and pastures are concentrated and more than 80% of the population of the republic lives.

We performed preliminary assessments of agricultural land degradation for the administrative districts of the Central and Western agricultural zones of Tuva. When calculating the cadastral value, account was taken of summary data and correction factors (Tables 2–5), which are necessary as derivatives in the above for-

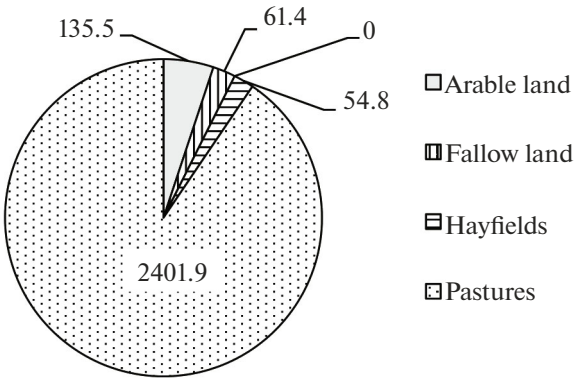

Fig. 2. The structure of agricultural land in the Republic of Tyva, thou ha (*Doklad* ..., 2020).

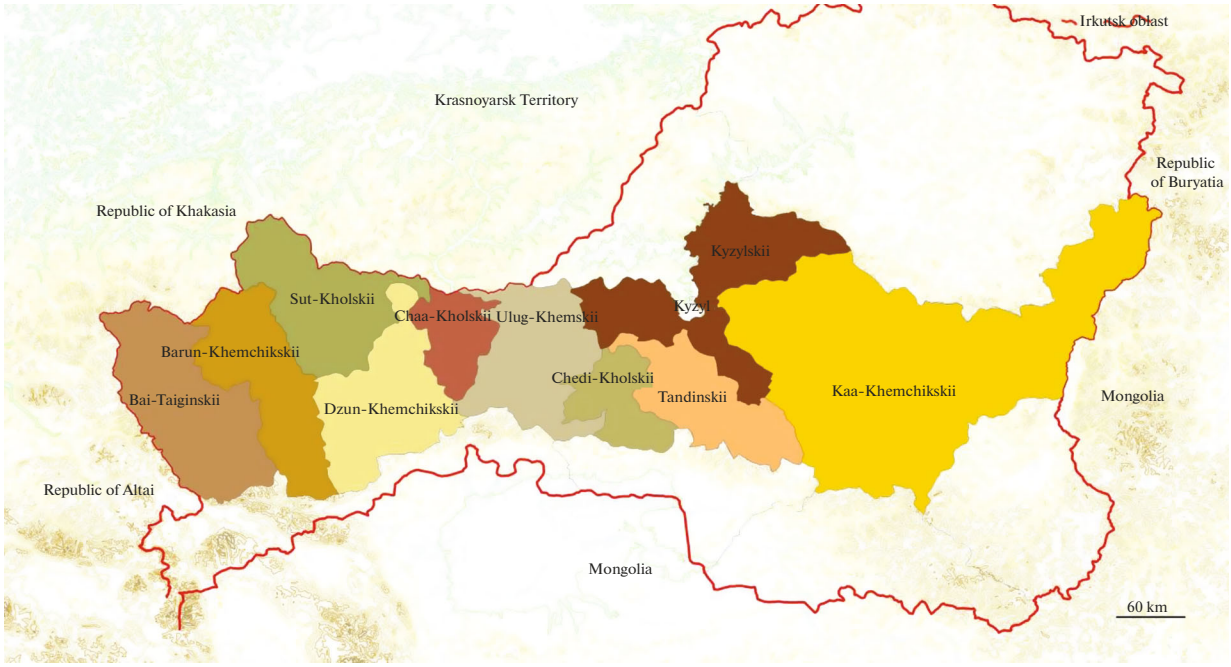

Fig. 3. The map-scheme of the regions of the Central and Western agricultural zones in the Republic of Tyva.

mula. The calculation of damage (in rubles) was made according to the above formula. For example, let us take the Bai-Taiginskii district: Cs, the cost standard is the cadastral value (Table 2), is 3500 rub/ha, S, the area of degraded agricultural land, is 63630 ha, and Ce, the coefficient of the ecological situation of the territory of the Republic of Tyva, which is part of the Eastern-Siberian economic region of the Russian Federation, is 1.1. The coefficients are introduced to take into account the total impact of soil and land degradation on the ecological situation. The territorial bodies of the Ministry of Natural Resources of Russia

Table 2. The cadastral value and area of agricultural land (including degraded land) for the districts of the Republic of Tyva

Districts (kozhuuns)	Districts (kozhuuns) (*Statisticheskii ezhegodnik*..., 2020)	Cadastral cost, rub/ha (*Postanovleniye* ..., 2017)	Water erosion	Deflation	Mixed manifestation of erosion and deflation	Salinization	Area of degraded agricultural land, ha (according to the FSBI State Station of Egrochemical Service "Tuvinskaya" for 2019–2021; *Gosudarstvennyi doklad*..., 2020)	Degree of degradation, %
Bai-Taiginskii	248559	3500	1900	56500	5000	230	63630	25.6
Dzun-Khemchikskii	254241	3400	1000	99700	500	1100	102300	40.2
Kyzylskii	235292	7400	1100	160000	1990	2000	165090	70.2
Sut-Kholskii	122040	3900	1000	64550	770	1880	68200	55.9
Tandinskii	118100	4800	1000	81970	640	790	84400	71.5
Chaa-Kholskii	166665	4500	2280	98940	270	310	101800	61.1
Chedi-Kholskii	116081	3900	33000	35000	1000	1200	70200	60.5

Table 3. The annual income per unit area for the districts of the Republic of Tyva

Districts (kozhuuns)	Income from agricultural products, thou rub (*Statisticheskii sbornik* ..., 2021)	Agricultural land area, ha (*Statisticheskii ezhegodnik* ..., 2021)	Annual income per unit area, rub/ha
Bai-Taiginskii	355922	248559	1431.94
Dzun-Khemchikskii	551541	254241	2169.36
Kyzylskii	533254	235292	2266.35
Sut-Kholskii	452654	122040	3709.06
Tandinskii	378679	118100	3206.43
Chaa-Kholskii	440651	166665	2643.93
Chedi-Kholskii	198646	116081	1711.27

Table 4. The values of the conversion factor (Cr) depending on the period of time for the recovery of soils and lands (*Metodika opredeleniya* ..., 1994)

Duration of the recovery period	Conversion coefficient	Duration of the recovery period	Conversion coefficient
1 year	0.9	8–10 years	5.6
2 years	1.7	11–15 years	7.0
3 years	2.5	16–20 years	8.2
4 years	3.2	21–25 years	8.9
5 years	3.8	26–30 years	9.3
6–7 years	4.6	31 and more years	10.0

Table 5. The cadastral valuation of agricultural land in the districts of the Central and Western zones of the Republic of Tyva, taking into account soil degradation and environmental damage

Districts (kozhuuns)	Cadastral cost, thou rub/ha	Damage calculated according to the formula, thou rub	% of loss
Bai-Taiginskii	869956.5	143192.8	16.4
Dzun-Khemchikskii	864419.4	352740.6	40.8
Kyzylskii	1741160.8	1277367.3	73.3
Sut-Kholskii	475956.0	388576.3	81.6
Tandinskii	566880.0	559926.4	98.7
Chaa-Kholskii	749992.5	549536.7	73.2
Chedi-Kholskii	452715.9	288795.7	63.7
In total for the Central and Western zones	**5721081.1**	**3560135.8**	**63.9**

and Roskomzem adjust the coefficients by a joint decision and also introduce the necessary indicators for the types of soil and land degradation based on natural and climatic conditions (*Metodika opredeleniya* ..., 1994); Cd, the conversion factor depending on the change in the degree of soil and land degradation (from 0 to 1); in the Bai-Taiginskii district the degree of soil degradation in agricultural land is 25.6%, i.e. the correction factor is 0.26; Ci is 1.0 (in this case, we consider agricultural land, i.e. other lands); Ai, annual income per unit area, rub/ha (Table 3), is 1431 rub/ha; Cr, the conversion factor depending on the period of land recovery on the example of the Bai-Taiginsky district, is 0.9 (1 year; Table 4). We make a calculation: damage (Bai-Taiginskii district) = 35.0 thou rubles × 63630 ha × 1.1 × 0.25 × 1.0 + 1.431 thou rubles × 63630 ha × 0.9 = 61243.8 thou rubles + 81949.0 thou rubles = 143192.8 thou rubles (Table 5).

CONCLUSIONS

As a result of calculations, the environmental damage to agricultural lands in the Central and Western agricultural zones of the Republic of Tyva is estimated at more than 3.5 bln rubles, which is 62.2% of the cadastral value of agricultural land. The greatest damage in percentage terms was revealed in the central agricultural regions: Tandinskii district (98.7%), Kyzylskii district (73.3%) and old agricultural Chaa-Kholskii district (73.2%). The greatest damage in monetary terms was observed in the Kyzylskii district (1.2 bln rubles), Tandinskii district (0.5 bln rubles) and Chaa-Kholskii district (0.5 bln rubles). The least damage both in percentage terms and in monetary terms is observed in the livestock-breeding Bai-Taiginskii district (16% and 0.1 bln rubles, respectively).

These cost losses must be taken into account to calculate the market value, which directly depends on the

cadastral value. Using this method, it is possible to calculate the damage for other categories of land by changing the correction factors.

Thus, the development of the agricultural sector of the republic requires not only capital investments in fixed assets of enterprises of the agro-industrial complex, which include buildings and structures, equipment, agricultural machinery, etc. We carried out preliminary assessments for some areas of the Central and Western agricultural zones of the republic; nevertheless, the results of the assessment show that it is necessary to further study the processes of degradation of agricultural lands in order to carry out scientifically based measures to improve their quality.

FUNDING

The study was financially supported by the Russian Foundation for Basic Research within the framework of scientific project no. 19-29-05208\19 mk "Ecological and Economic Assessment of the Degradation of Agricultural Lands in the Republic of Tyva".

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests. The authors declare that they have no conflict of interest.

REFERENCES

Agroklimaticheskie resursy Krasnoyarskogo kraya i Tuvinskoi ASSR (Agro-Climatic Resources of the Krasnoyarsk Krai and the Tuva Autonomous Soviet Socialist Republic), Leningrad: Gidrometeoizdat, 1974.

Badmaev, A.G., Ecological and economic assessment of agricultural land in the Republic of Buryatia, taking into account soil degradation and environmental damage, *Zapiski Zabaikal'skogo Otdeleniya Russkogo Geograficheskogo Obshchestva,* 2016, pp. 137–146.

Bazilevich, N.I. and Pankova, E.I., Experience in classifying soils by salinity, *Pochvovedenie,* 1967, no. 12, pp. 113–123.

Belek, A.N., Solov'eva, V.M, and Poryadina, E.A., Agroecological soil monitoring of agricultural territory in the Republic of Tyva, *Agrokhim. Vestn.,* 2017, no. 2, pp. 55–57.

Bondarenko, E.V., Experience in taking into account soil ecosystem services in the assessment of land degradation (on the example of the Educational and Experimental Soil and Ecological Center of Moscow State University)), *Extended Abstract of Cand. Biol. Dissertation,* Moscow: Moscow State Univ, 2016.

Dabiev, D.F. and Sambuu, A.D., Ecological and economic assessment of agricultural land in the Ubsu-Nur depression taking into account soil degradation, *Fundam. Issled.,* 2020, no. 4, pp. 21–25.

Decree of the Government of the Republic of Tyva No. 139, dated June 4, 2017. On approval of the results of the state cadastral valuation of agricultural land in the Republic of Tyva. https://base.garant.ru/47803174/#friends. Cited November 14, 2021.

Doklad o sostoyanii i ispol'zovanii zemel' Respubliki Tyva v 2019 g (Report on the State and Use of Lands of the Republic of Tyva in 2019), Kyzyl: Upravlenie Federal'noi Sluzhby Gosudarstvennoi Registratsii, Kadastra i Kartografii po Respublike Tyva, 2020a.

Doklad o sostoyanii i ispol'zovanii zemel' v Respublike Tyva v 2019 godu (Report on the State and Use of Lands in the Republic of Tyva in 2019), Kyzyl: Upravlenie Federal'noi Sluzhby Gosudarstvennoi Registratsii, Kadastra i Kartografii po Respublike Tyva, 2020b.

Ekonomika Tuvinskoi ASSR (The Economy of the Tuva ASSR), Klopov, S.V, Ed., Kyzyl: Tuvinskoye Knizhnoye Izdatel'stvo, Tuvinskiy Nauchno-Issled. Inst. Yazyka, Literatury i Istorii, 1973.

Gosudarstvennyi doklad o sostoyanii i ob okhrane okruzhayushchei sredy Respubliki Tyva v 2020 godu (State Report on the State and Protection of the Environment of the Republic of Tyva in 2020), Kyzyl: Ministerstvo Prirodnykh Resursov i Ekologii, 2021.

Karmanov, I.I. and Bulgakov, D.S., *Metodika pochvenno-agroklimaticheskoi otsenki pakhotnykh zemel' dlya kadastra* (Methodology for Soil And Agro-Climatic Assessment of Arable Land for the Cadastre), Moscow: OOO "APR", 2012.

Kozhuuny i goroda Respubliki Tyva: Statisticheskii sbornik (Kozhuuns and Cities of the Republic of Tuva: Collection of Statistics), Kyzyl: Tyvastat, 2016.

Kust, G.S., Modern global challenges of land degradation: International approaches and ways of adaptation at the national level, in *Degradatsiya zemel' i opustynivanie: problemy ustoichivogo prirodopol'zovaniya i adaptatsii* (Land Degradation and Desertification: Problems of Sustainable Nature Management and Adaptation), Moscow: MAKS Press, 2020, pp. 11–17.

Lee, H., Honda, Y., Lim, Y.-H., Guo, Y.L., Hashizume, M., and Kim, H., Effect of Asian dust storms on mortality in three Asian cities, *Atmos. Environ.,* 2014, no. 89, pp. 309–317.

Makarov, O.A., Tsvetnov, E.V., and Ermiyaev, Ya.R., Ecological and economic assessment of land: Methodology and development prospects, *Ispol'zovanie i Okhrana Prirodnykh Resursov v Rossii,* 2016, no. 4, pp. 14–28.

Makarov, O.A., Strokov, A.S., Tsvetnov, E.V., Bondarenko, E.V., Kubarev, E.N., Chistova, O.A., and Ermiyaev, Ya.R., Approbation of the methodology of ecological and economic assessment of land degradation, *Agrokhim. Vestn.,* 2017a, vol. 3, no. 3, pp. 55–59.

Makarov, O.A., Yakovlev, A.S., Strokov, A.S., Tsvetnov, E.V., and Ermiyaev, Ya.R., Methodology of ecological and economic assessment of land degradation at various hierarchical levels of the administrative and economic structure of Russia, *Ispol'zovanie i Okhrana Prirodnykh Resursov v Rossii,* 2017b, no. 3, pp. 29–36.

Makarov, O.A., Strokov, A.S., Tsvetnov, E.V., Kubarev, E.N., Abdulkhanova, D.R., Kudelin, V.N., and Marakhova, N.A., Economic assessment of action and inaction in relation to degraded lands in the Belgorod Oblast, *Zemledelie,* 2018, no. 7, pp. 3–5.

Makarov, O.A., Strokov, A.S., Tsvetnov, E.V., Kubarev, E.N., Abdulkhanova, D.R., and Kudelin, V.N., Ecological and economic assessment of land degradation in the Tula Oblast, *Problemy Agrokhimii i Ekologii,* 2019, no. 1, pp. 44–52.

Makarov, O.A., Strokov, A.S., Tsvetnov, E.V., Abdulkhanova, D.R., Krasil'nikova, V.S., and Shcherbakova, L.S.,

Assessment of damage from soil and land degradation in the subjects of the Russian Federation, *Zemledelie,* 2020, no. 6, pp. 3–6.

Makarov, O.A., Strokov, A.S., Tsvetnov, E.V., and Abdulkhanova, D.R., Approbation of various approaches to environmental and economic assessment of soil and land degradation, *IOP Conference Series: Earth and Environmental Science,* 2021, vol. 862. pp. 1–9.

Metodika ischisleniya razmera vreda, prichinennogo pochvam kak ob"ektu okhrany okruzhayushchei sredy. Utverzhdena prikazom Minprirody Rossii № 238 ot 8 iyulya 2010 g. (Methodology for Calculating the Amount of Damage Caused to Soils as an Object of Environmental Protection. Approved by Order of the Ministry of Natural Resources of Russia no. 238 as of July 8, 2010), 2010.

Metodika opredeleniya razmerov ushcherba ot degradatsii pochv i zemel' (Methodology for Determining the Amount of Damage from Soil and Land Degradation), Moscow: Komitet Rossiiskoi Federatsii po Zemel'nym Resursam i Zemleustroistvu, 1994.

Nauchnye osnovy predotvrashcheniya degradatsii pochv (zemel') sel'skokhozyaistvennykh ugodii Rossii i formirovaniya sistem vosproizvodstva ikh plodorodiya v adaptivno-landshaftnom zemledelii. Teoreticheskie i metodicheskie osnovy vosproizvodstva plodorodiya (Scientific Basis for the Prevention of Soil (Land) Degradation of Agricultural Lands in Russia and the Formation of Systems for the Reproduction of Their Fertility in Adaptive Landscape Agriculture. Theoretical and Methodological Foundations of Fertility Reproduction.), Frid, A.S., Koroleva, I.E., Bulgakov, D.S., Karmanov, I.I., Shishkonakova, E.A., and Gribov, V.V., Eds., Moscow: Pochvennyi Inst. im. V.V. Dokuchaeva Rossel'khozakademii, 2013, vol. 2.

Nosin, V.A., *Pochvy Tuvy* (Soils of Tuva), Moscow: Akad. Nauk SSSR, 1963.

Otsenka zemel'nykh resursov (Assessment of Land Resources), Antonov, V.P., Loiko, P.F., et al., Eds., Moscow; Institut Otsenki Prirodnykh Resursov, 1999.

Poryadok opredeleniya razmerov ushcherba ot zagryazneniya zemel' khimicheskimi veshchestvami. Utverzhden Komutetom Ros. Federatsii po zemel'nym resursam i zemleustroistvu i Ministerstvom okhrany okruzhayushchei sredy i prirodnykh resursov Rossiiskoi Federatsii v noyabre 1993 g. (The Procedure for Determining the Amount of Damage from Land Pollution by Chemicals. Approved by the Committee of the Russian Federation on Land Resources and Land Management and by the Ministry for the Protection of the Environment and Natural Resources of the Russian Federation in November 1993), Moscow: B, 1993.

Postanovlenie Pravitel'stva RF ot 24 dekabrya 2014 g. N 1471 "O normativakh platy za vybrosy v atmosfernyi vozdukh zagryaznyayushchikh veshchestv statsionarnymi i peredvizhnymi istochnikami, sbrosy zagryaznyayushchikh veshchestv v poverkhnostnye i podzemnye vodnye ob"ekty, v tom chisle cherez tsentralizovannye sistemy vodootvedeniya, razmeshchenie otkhodov proizvodstva i potrebleniya" (Decree of the Government of the Russian Federation N 1471 "On the Standards of Payment for Emissions of Pollutants into the Atmospheric Air by Stationary and Mobile Sources, Discharges of Pollutants into Surface and Underground Water Bodies, Including Through Centralized Sewerage Systems, Disposal of Production Waste and Consumption" dated December 24, 2014).

Sobolev, S.S., *Razvitie erozionnykh protsessov na territorii Evropeiskoi chasti SSSR i bor'ba s nimi* (Development of Erosion Processes on the Territory of the European Part of the USSR and Their Control), Moscow: Akad Nauk SSSR, 1948, vol. 1.

Sobolev, S.S., *Metodika polevogo opyta po bor'be s vodnoi i vetrovoi eroziei pochv* (Methodology of the Field Experiment to Combat Water and Wind Erosion of Soils), Moscow: Pochvennyi Institut im. V.V. Dokuchaeva. VASKhNIL, 1970.

Soldatov, V.P., Distribution and specialization of agriculture in the Tuva ASSR, *Extended Abstract of Cand. Econ. Dissertation,* Moscow, 1967.

Sotsial'no-ekonomicheskie pokazateli gorodskikh okrugov i munitsipal'nykh raionov Respubliki Tyva v 2018 godu. Statisticheskii sbornik no. 1.33.077RT (Socio-economic Indicators of Urban Districts and Municipal Districts of the Republic of Tyva in 2018. Statistical Collection no. 1.33.077RT), Krasnoyarsk: Sel'skoe Khozyaistvo, Okhota i Okhotnich'e Khozyaistvo, Lesovodstvo v Respublike Tyva, 2019.

Statisticheskii ezhegodnik Respubliki Tyva za 2018 god (Statistical Yearbook of the Republic of Tyva for 2018), Kyzyl: Upravlenie Federal'noi Sluzhby Gosudarstvennoi Statistiki po Krasnoyarskomu Krayu, Respublike Khakasiya i Respublike Tyva, 2019.

Statisticheskii ezhegodnik Respubliki Tyva za 2019 god (Statistical Yearbook of the Republic of Tyva for 2019), Kyzyl: Upravlenie Federal'noi Sluzhby Gosudarstvennoi Statistiki po Krasnoyarskomu Krayu, Respublike Khakasiya i Respublike Tyva, 2020.

Statisticheskii ezhegodnik Respubliki Tyva za 2020 god (Statistical Yearbook of the Republic of Tyva for 2020), Kyzyl: Upravlenie Federal'noi Sluzhby Gosudarstvennoi Statistiki po Krasnoyarskomu Krayu, Respublike Khakasiya i Respublike Tyva, 2021.

Statisticheskii sbornik "Sel'skoe khozyaistvo, okhota i okhotnich'e khozyaistvo, lesovodstvo v Respublike Tyva" no. 1.34.021RT (Statistical Collection "Agriculture, Hunting and Game Management, Forestry in the Republic of Tyva" no. 1.34.021RT), Kyzyl, 2021.

Tsvetnov, E.V., Marakhova, N.A., Makarov, O.A., et al., Experience in approbation of societal land value as a basis for ecological and economic assessment of damage from land degradation, *Eurasian Soil Sc.,* 2019, vol. 52, no. 10, pp. 1298–1305.

Yakovlev, A.S., Makarov, O.A., Kiselev, S.V., Molchanov, E.N., Belugin, A.Yu., Bogdanova, T.V., Bondarenko, E.V., Buivolova, A.Yu., Bulgakov, D.S., Giorgadze, S.R., Glazunov, G.P., Dubrovina, I.A., Evdokimova, M.V., Ermiyaev, Ya.R., Zabolotneva, K.M., Krasil'nikov, P.V., Krasil'nikova, V.S., Mirzabaev, A.M., Ogorodnikov, S.S., Pasikova, A.S., Savin, I.Yu., Sidorova, V.A., Sorokin, A.S., Strokov, A.S., Tsvetnov, E.V., Shishkonakova, E.A., Yurkevich, M.G., and Yakhtanigova, T.B., *Ekologo-ekonomicheskaya otsenka degradatsii zemel'* (Ecological and economic assessment of land degradation), Moscow: MAKS Press, 2016.

Translated by L. Solovyova