SOIL-AGROMELIORATIVE REGIONALIZATION AS AN INFORMATION BASE FOR THE SOIL COVER INVENTORY OF AGRICULTURAL LANDS IN RUSSIA

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Under consideration is a version of the regionalization revised with the aim to renew taxons, to give a new interpretation of farming systems and to specify the qualitative and quantitative characteristics of the soil cover in agricultural areas. It is of great interest from the historical viewpoint, permitting to study the stages in the development of the purposeful regionalization. The materials presented in this paper may be useful for elaborating a new specialized regionalization using the modern GIS-technologies for the further development of agriculture in the nearest future.

Keywords: soil-agromeliorative regionalization, landscape–soil–environmental and climatic characteristics of the soil cover, soil-agromeliorative regions, claster analysis.

The territory of Russia reveals a great diversity of natural (soil–climatic) conditions, which determine the soil formation processes, properties and fertility of soils, their resistance to different kinds of degradation and the possible efficient use of the soil cover for solving regional tasks in the further development of agriculture.

It is known that the rational use of the country's land resources is possible only when the state of soils and soil cover has been thoroughly studied. The anthropogenic effects on soils and the soil cover are varying in different natural zones and their peculiar features should be taken into complete account in agricultural management. This is clearly reflected in different kinds of land regionalization. The scientifically-grounded elaboration of a new purposeful regionalization using modern GIS-technologies may be realized as based upon the available regionalization of the same type. In view of this, the given paper is aimed to present a comprehensive analysis of different regionalization kinds and the soil-agromeliorative regionalization in particular.

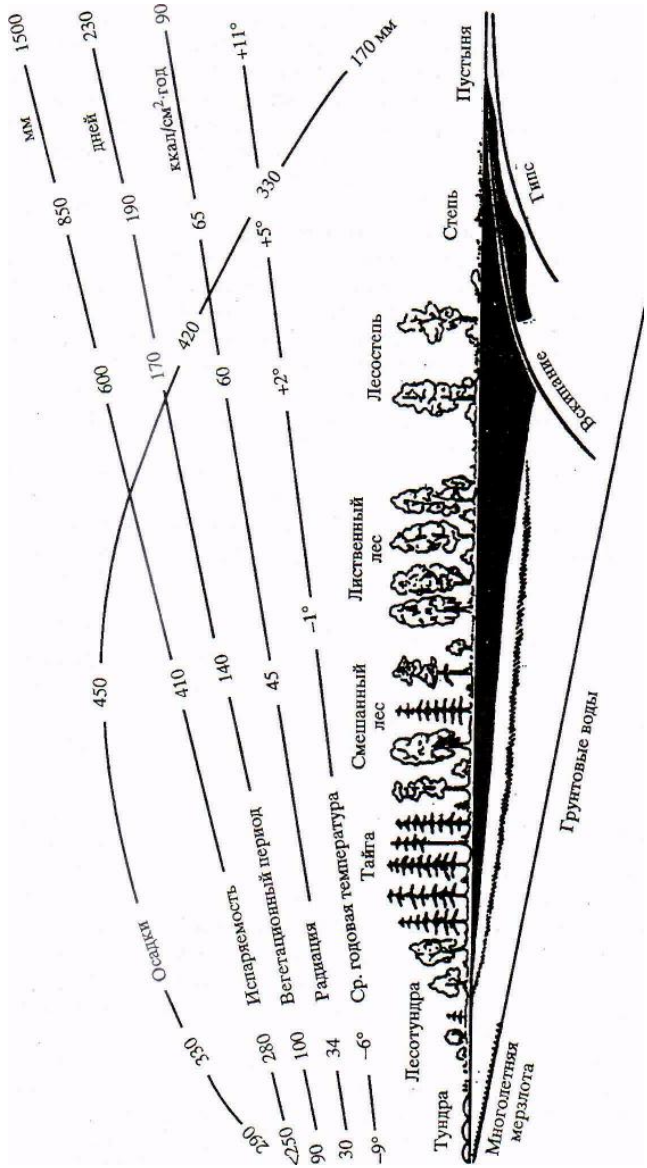

Fig.1. Scheme of changes in the climate, vegetation and soils in Eastern Europe directed from the north-west to the south-east towards the Pre-Caspian lowland (Walter, 1975, p.142)

In the XIX century V.V. Dokuchaev (1883) suggested the regionalization of the territory within the boundaries of chernozem distribution in European Russia and later on he offered the law of natural zonality, thus indicating a close interaction between the climate, soils, vegetation and animal kingdom (V.V. Dokuchaev, 1899). The latest studies in soil science served as evidence of Dokuchaev's idea (Fig.1).

This fact that is rather evident not only for Russia and soil science has been presented in a series of publications about the country's regionalization for different purposes appeared in the USSR in the mid-XX century. Among them are geobotanical [6, 5, 25, 47], geomorphological [7, 2], hydrological [42], soil-geographical [12, 10, 11], natural-historical [15], soil-geographical regionalization [32], physical-geographical [19, 20, 4], agroclimatic [45, 46], natural-agricultural [34, 35], natural [27, 36], climatic [40, 23, 1], landscape [26, 43, 44], forest [22, 24], natural-meliorative [49, 16, 17], etc.

The above kinds of regionalization have the purpose to provide the agriculture with the natural information base and to take into consideration regional peculiar features of the agricultural production. Of great interest is the natural-agricultural regionalization of the USSR elaborated in the 1970s. It distinguishes 14 zones and 47 provinces at the plain territory including 11 zones and 36 provinces in Russia; they were identified by using 6 indices such as the continentality coefficient, the lower and upper boundaries of effective temperatures, moisture coefficient and the bioclimatic index.

The results of claster analysis permitted to elaborate a quantitative conception about the interaction between these natural zones and indices characterizing them in space [37].

As seen from Fig. 2, the level of natural similarity or difference between the zones is quite different, thus permitting to distinguish or not distinguish them. For example, there is no necessity to recognize 8 semi-desert and 9 desert zones, whose level of natural-agricultural similarity makes up 94%. The similarity level between 3–5 and 6–7 clasters doesn't exceed 58%, or there is the same similarity between 8–12 claster and the zone 13. In the other words, the lower is the similarity level the greater is the area of regionalization to be at another taxonomic level (region, belt, etc.). In general, such an analysis serves as an addition to the concept of the territory differentiation and helps to make

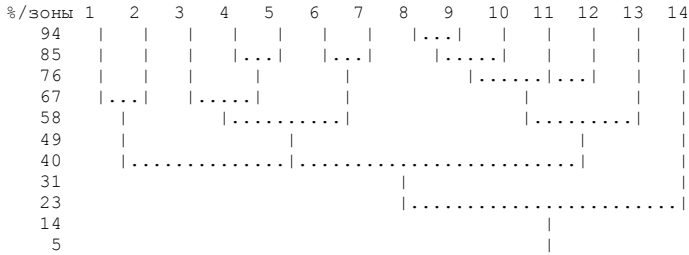

Fig. 2. Dendrogram of natural-agricultural zones.

optimal decisions. It seemed to be a basis for a number of purposeful regionalization.

Today, in the period of transition to the market relations in the country the distribution of soil-agromeliorative resources in several regions resulted from estimating their natural potential by means of different regionalization kinds remains in the interests of the State. In view of this, it is very important to mention the soil-agromeliorative regionalization of arable lands in the USSR elaborated in the 1980s of the XX century. However, after disintegration of the USSR and changes in political and social-economic conditions in the Russian Federation it became necessary to revise the above regionalization with the due account of new boundaries and areas occupied by arable lands in Russia. It was specified by using the information on soil-geographical and natural-agricultural regionalization of the USSR in which some contours of agricultural areas have been generalized [48].

The complex soil-agromelorative regionalization of arable lands in the USSR [37] included soil-agromeliorative regions provided with detail qualitative and quantitative characteristics of the soil cover at the territory of agricultural areas and the data about agricultural management practices according to their effects on agro-ecosystems [50].

The same taxonomic units remained in the revised soil-agromeliorative regionalization – soil-agromeliorative zone and soil-agromeliorative region in plain and the mountain area and mountain region in the mountains. The zones are distinguished according to the heat and moisture balance, regions – according to temperature differences (in meridional direction), moisture conditions and climate continentality (in latitudinal direction). As distinct from regionalization of the territory in the USSR a new version of this regionalization contains

9 soil-agromeliorative zones, one group of mountain areas, 23 regions in plain and 3 regions in the mountains. The information was also taken into consideration to show the basic adverse natural-anthropogenic processes of soil degradation (Fig.3).

Every region is provided with the characteristics of the areas occupied by arable lands including irrigated and drained ones, the soil cover and a share of each soil in it, the structure of areas under crops and a share of areas occupied by a definite crop, the data about soil supply with elements so vital for cultural crop nutrition including nitrogen, phosphorus, potassium and the required rates of organic fertilizers for self-supporting humus balance, adaptive-landscape farming systems (as distinct from zonal ones) in the region with account of management practices (for instance, forest–steppe, agro–forest–ameliorative, water–accumulating, irrigational tillage, mold–boarding plowing at a different depth as well as the measures to decrease the soil acidity, to accumulate the humus in soil, to protect against erosion or excessive compaction of soil). All these data are shown in digitized form (Table 1, 2). Moreover, there are data about 11 agro–climatic indices including the heat and water supply, severe winters, the climate continentality for one or a group of regions.

The revised version of the given regionalization reflects the interaction between agricultural and agro–ameliorative practices and may serve as a historical basis for forecasting the changes in great administrative regions (Fig.4). The Table demonstrates the regionalization taxons, but some of them need to be additionally discussed.

The zone of tundra arctic soils embraces the Euro-Asian territory with the temperate continental climate which is excessively humid and predominated by the permafrost and cryogenic processes. The agriculture is local by nature and meets only the requirements of native people using close hot-houses, artificial thermoregulation and the prolonged light day.

The northern and middle taiga zone is the zone of different-textured gley podzolic and frozen taiga soils. With respect to soil amelioration this zone is subdivided into 4 specific regions; the agriculture takes place only in the second region situated in Eastern Europe.

Table 1. The landscape-soil-agronomical characteristics of the territory in Russia and measures recommended for soil improvement

No. Index of region, zone	Soil-agromeliorative region, zone	Soils, indices, the share in %	Area under crops %	Structure of areas under crops, %					Supply degree			Recommended measures, indices, share in %
				cere-als	tilled	fal-low	per-ennial grass	annual grass and legume	N	P	K	
1	Euroasian, tundra	$А_5$ ПБ$_3$ (По + Г)$_2$	–	–	–	–	–	–	–	–	–	$Т_{10}$
2(2а)	European, taiga	$П_8$ (Пб + А)$_2$	0.9	+	–	–	–	–	1	1.2	3	Ок$_1$ Тсг$_8$ Ки$_6$ Кд$_4$ Гтк$_{10}$ Аака$_{10}$
3(2б)	West Siberian, taiga	$П_8$ (Пб + А)$_2$	0.1	+	–	–	–	–	1	1.2	2	Ок$_1$ Ки$_7$Кд$_2$ Тсг$_{10}$ Гтка$_{10}$ Афка$_{10}$
4(2в)	East Siberian, frozen taiga	Пл$_5$ Дг$_3$ А$_2$П?	0.1	+	–	–	–	–	1	1.2	2.3	Тм$_4$Тсг$_6$ Ок$_2$Ки$_3$Кд$_4$ Гтк$_{10}$ Афка$_{10}$
5(2г)	Okhotsk-Kamchatka, forest taiga	$А_4$ Дг$_3$ Мт$_2$П?	0.1	+	–	–	–	–	1	1.2	2	Тм$_2$Тсг$_4$ Ок$_3$Ки$_4$ Гтк$_{10}$ Афкм$_{10}$
6 (3а)	West Russian, taiga forest	Пд$_6$ Пб$_2$ (Дг+ Дк+ А)$_2$	0.2 0.1*	48	14	1	30	8	2	2	2	Оддр$_3$ Ки$_7$Кд$_3$ Гнт$_7$Гс$_3$ Афка$_{10}$Ам$_3$ Эп$_2$Мк
7(3б)	Central taiga forest	Пд$_9$ Пб$_1$	10.4 0.5*	50	16	3	27	4	1.2	1	1.2	Оддр$_1$ Ки$_3$Кд$_2$ Гтн$_7$Гс$_2$ Афка$_{10}$Ам$_2$ Эп$_3$
8(3в)	Pre-Ural taiga forest	Пд$_9$ Пб$_1$	4.7	59	15	6	15	5	1.2	1.2	1.2	Вс$_1$ Ки$_8$Кд$_2$ Гтн$_8$ Афеа$_8$ Эпо$_2$
9(3г)	West Siberian, taiga forest	Пд$_9$ Пб$_1$	1.5 0.4*	60	14	6	9	5	1	1	2	Ок$_2$Оам$_1$Ки$_7$Кд$_2$Гтн$_8$ Афка$_8$Эп$_2$
10(3д)	Middle Siberian taiga forest	Пд$_{10}$ Пб?	1.0 0.1*	54	15	–		–	1	1	2.3	Ок$_1$Ки$_8$Гтн$_{10}$ Аф$_9$ Эп$_3$

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No. Index of region, zone	Soil-agromeliorative region, zone	Soils, indices, the share in %	Area under crops %	Structure of areas under crops, %					Supply degree			Recommended measures, indices, share in %
				cere-als	tilled	fal-low	per-ennial grass	annual grass and legume	N	P	K	
11(3е)	Far East, meadow-taiga forest	$Лб_4$ $Лч_2$ $Лг_2$ $(Дг+А)_2$	1.5 0.5*	45	32	–	–	–	1	1	2	$Ок_1Оам_1$ $Ки_6Гтн_8$ $Афак_8$ $Эпо_2$
12(4а)	Central Chernozem forest steppe	$Л_3$ $Чв_3$ $Чт_3Чл_1$	20.8 0.4**	56	27	4	5	8	3	1.2	2	$Влс_6Идм+д_1$ $Ки_2$ $Гтн_6$ $Афк_6$ $Эпо_5$
13(4б)	Volga forest steppe	$Л_3$ $Чв_4$ $Чт_3$	9.2 0.1**	63	16	7	5	9	3.4	1.2	2.3	$Влс_6Идм+д_1Ки_3$ $Гтн_8$ $Афк_6Эпо_4$
14(4в)	West Siberian, meadow-steppe	$Л_3$ $Чв_4$ $Чл_2$ $Члсн_1$	9.6 0.1”	60	13	7	11	5	2.3	1	3.4	$Вск_7Идм+м_1$ $Ки_2$ $Гтн_6$ $Аф_6$
15(4г)	Pre-Altai forest steppe	$Л_2Чв_7$ $Чт_1$	3.7	60	8	–	–	–	2.3	1.2	3.4	$Вск_8Идм+д_1$ $Гтн_7$ $Аф_8Эп_4Эв_5$
16(4д)	Middle Siberian, forest steppe	$Л_4$ $Чв_4$ $(Чл+Дк)_2$	2.5 0.4**	50	10	–	–	–	2.3	1	2	$Вск_{10}Идм+д_1$ $Ки_4$ $Гтн_8$ $Аф_8$ $Эпв_5$
17(5а)	Pre-Caucasian, steppe	$Чок_5$ $Чюк_2$ $(Чв+Чл+Л)_2$	8.1 0.1**			–	–	–	2.3	3	1	$Вл_8Идм+д_1$ $Гтн_8$ $Афм_6Эпв_6Сгзм$ Зв
18(5б)	Central steppe	$Чо_4$ $Чю_5Чсн_1$	8.6 0.1**	55	24	8	6	7	2.3	1	3.4	$Вл_{10}Идм+д_1$ $Гтн_8$ $Афм_8$ $Эпв_4Сзмг$
19(5в)	Trans-Volga, steppe	$Чо_4$ $Чю_4$ $(Чсн+Кт)_2$	6.7 0.3**	57	26	3	5	6	2.3	1	3	$Влс_{10}Идм+д_1$ Гтк9 Афк9 Эпо4 $Смзм_1$
20(5г)	West-Siberian, steppe	$Чо_4$ $Чю_4$ $(Чсн+Члсн)_2$	7.8 0.2**	70	16	7	11	3	2.3	1.2	3.4	$Вс_9Идм+д_1Гтк_8$ $Аф_8$ $Эпв_2Зф$ $См_2$
21(5д)	Middle-and East Siberian, steppe	$Чо_4$ $Чю_4$ $(Чл+Кт)_2$	2.6	75	8	8	–	–	2.3	1.2	2	$Вс_9Идм+д_1$ $Гтн_8Аф_8$ $Эпо_4$

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No. Index of region, zone	Soil-agromeliorative region, zone	Soils, indices, the share in %	Area under crops %	Structure of areas under crops, %					Supply degree			Recommended measures, indices, share in %
				cere-als	tilled	fal-low	per-ennial grass	annual grass and legume	N	P	K	
22(6а)	East Siberian, dry steppe	$К_8$ (Ксн+Кл)$_2$	12.6 0.4**	65	5	–	–	–	1	1	3	Влк$_{10}$Иол$_1$ Гтк$_8$ Аф$_8$ Эпо$_2$Эв$_2$
23(6б)	West Siberian, dry steppe	$К_7$ (Ксн+Кл) $_3$	1.1 0.3**	72	4	10	–	–	1.2	1.2	2.3	Вск$_{10}$Иол$_1$ Гтк$_8$ Аф$_8$ Эпв$_3$Зф$_2$См$_2$
7	South-European semi-desert zone	$К_4$ Ксн$_3$ Кл$_2$А$_1$	0.5**	69	3	9	–	–	1	1.2	3	Ио+од$_{10}$Гкн$_8$ Афм$_5$ Эи$_2$Зв$_6$
8	Pre-Caspian desert zone	Сб$_2$ Сбсн$_5$ Пп$_2$	0.1**	–	–	–	–	–	1	1	3	Ио+од$_9$ Гкт$_8$ Афм$_4$ Эио$_4$ Зв$_2$Зп
9	Pre-Caucasian subtropical wet-forest zone	Ж$_7$ (Лг+А+Аб)$_3$	0.06	–	–	–	–	–	–	–	–	Окдй$_1$Ки$_9$Гкв$_9$ Афм$_9$ Эпо$_9$

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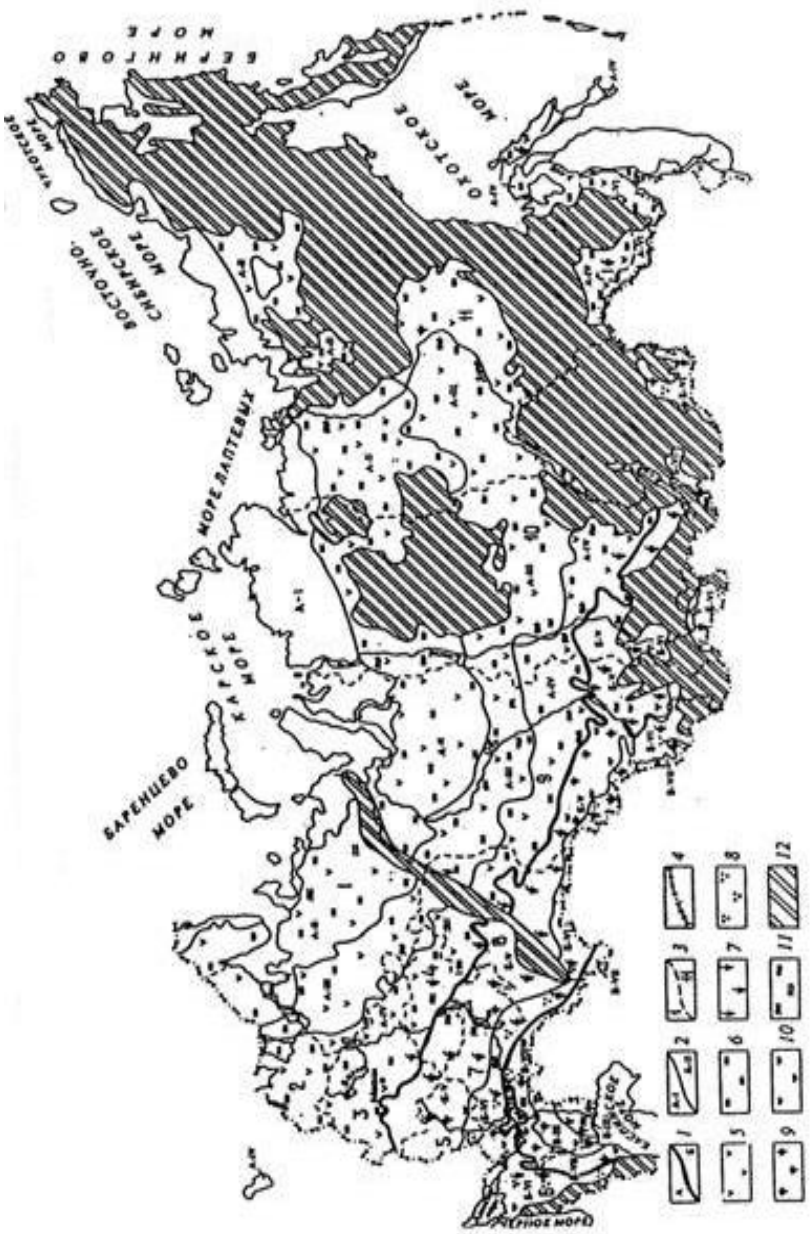
Table 2. Agroclimatic characteristics of soil-agromeliorative regions, zones

Index	Soil-agromeliorative region, zone	Heat supply			Winter severety			Water supply				Climate continentality after Ivanov
		sum t >10°C		Period duration with t° of air >10°C	the cold month, t°C		Snow cover thickness, см	Annual precipitation, mm	Reserves of productive moisture in 1 m of soil for the vegetation period, mm		Ivanov's moisture coefficient	
		air	soil at a depth 0.2 m		air	soil at depth 0.2 m			at the beginning	at the end		
1	Euroasian tundra	0–600	0–400	0–50	–6...–34	–1...–10	40–85	200–400	No information		1.33	71–178
2(2а)	European taiga	400–1650	150–1700	40–112	–10...–16	–2...–4	55–95	400–700	200	200	1.33	110–175
3(2б)	West- Siberian taiga	400–1700	150–1750	36–113	–20...–35	–6...–8	45–95	300–500	200	200	1.0–1.33	166–240
4(2в)	East-Siberian frozen taiga	400–1500	150–1500	32–100	–23...–48	–12...–25	30–95	50–500	150–200	130–200	0.55–1.33	190–300
5(2г)	Okhotsk-Kamchatka forest taiga	400–1200	150–1150	30–80	–10...–25	–2...–7	60–100	1600–1000	200	200	1.0–1.33	108–196
6(3а)	West-Russian taiga forest	1600–2550	1650–2800	103–163	–2...–11	–0...–3	20–45	550–800	175–200	150–200	1.0–1.33	102–160
7(3б)	Central taiga forest	1600–2400	1650–2600	100–150	–8...–17	–1...–4	50–80	500–800	150–200	175–200	1.0–1.33	145–170
8(3в)	Pre-Ural taiga forest	1500–2200	1500–2350	105–125	–10...–17	–2...–5	50–70	500–650	150–200	150–200	1.0–1.33	165–195

Index	Soil-agromeliorative region, zone	Heat supply			Winter severety			Water supply				Climate continentality after Ivanov
		sum t >10°C		Period duration with t° of air >10°C	the cold month, t°C		Snow cover thickness, см	Annual precipitation, mm	Reserves of productive moisture in 1 m of soil for the vegetation period, mm		Ivanov's moisture coefficient	
		air	soil at a depth 0.2 m		air	soil at depth 0.2 m			at the beginning	at the end		
9(3г)	West-Siberian taiga forest	1500–1850	1500–1950	100–122	–16...–18	–4...–6	60–90	400–500	150–200	150–200	1.0–1.33	170–205
10(3д)	Middle Siberian taiga forest	1400–1600	1350–1900	90–104	–21...–27	–7...–10	30–50	300–400	150–175	150–175	0.77–1.00	210–240
11(3е)	Far East meadow-taiga forest	1000–2600	850–2800	76–130	–14...–22	–3...–8	30–90	500–1000	200	200	1.0– 1.33	Муссонный
12(4а)	Central Chernozem forest steppe	2000–2800	2100–3100	132–163	–8...–13	–1...–4	35–50	400–600	150–175	125–150	0.77–1.15	160–190
13(4б)	Volga forest steppe	1600–2500	1650–2700	106–149	–13...–16	–2...–5	40–80	400–600	125–175	125–150	0.77–1.00	180–194
14(4в)	West-Siberian meadow steppe	1800–2250	1850–2450	110–137	–17...–20	–4...–7	40–60	300–400	125–175	75–115	0.66–1.00	190–216
15(4г)	Pre-Altai forest steppe	1600–2050	1650–2150	102–129	–17...–19	–4...–6	45–100	400–800	125–175	125–150	0.66–1.15	194–210
16(4д)	Middle Siberian forest steppe	1400–1700	1350–1750	93–110	–18...–19	–5...–7	30–60	300–500	125–150	100–150	0.66–1.15	215–240
17(5а)	Pre-Caucasian steppe	2800–3600	3100–4050	166–190	–1...– 6	+0...–4	10–60	400–800	150–175	110–150	0.53–1.00	160–180

Index	Soil-agromeliorative region, zone	Heat supply			Winter severety			Water supply				Climate continentality after Ivanov
		sum t >10°C		Period duration with t° of air >10°C	the cold month, t°C		Snow cover thickness, см	Annual precipitation, mm	Reserves of productive moisture in 1 m of soil for the vegetation period, mm		Ivanov's moisture coefficient	
		air	soil at a depth 0.2 m		air	soil at depth 0.2 m			at the beginning	at the end		
18(5б)	Central steppe	2400–3300	2600–3700	145–179	–6...13	–2...–5	15–40	350–500	100–150	80–115	0.44–0.77	165–190
19(5в)	Trans-Volga steppe	2200–2800	2350–3100	138–156	–13...16	–4...–8	30–50	300–400	100–125	80–100	0.40–0.66	190–200
20(5г)	West-Siberian steppe	2000–2400	2100–2600	126–143	–19...–21	–6...–9	30–45	200–350	100–150	75–125	0.44–0.77	200–225
21(5д)	Middle-and-East-Siberian steppe	1400–2000	1350–2200	95–120	–19...–30	–8...–14	15–50	200–500	100–150	80–120	0.40–0.77	210–290
22(а)	East-European dry steppe	2600–3600	2850–4050	142–195	–2...–18	–0...–7	10–25	250–350	75–125	75–100	0.33–0.55	175–220
23(6б)	West-Siberian dry steppe	2200–2800	2350–3100	135–155	–15...–19	–6...–13	20–30	250–350	70–110	40–80	0.33–0.44	206–230
7	South-European semi-desert zone	2200–3600	2350–4050	136–188	–4...–18	–2...–12	10–25	100–300	50–100	25–75	0.12–0.33	180–250
8	Pre-Caspian desert zone	3000–4000	3300–4500	160–200	–5...–13	–3...–8	10–20	75–175	40–90	10–35	0.12–0.22	206–260
9	Pre-Caucasian subtropical wet-forest zone	4000–4400	4500–5000	200–240	+7...–1	+8...+1	10–15	800–3200	150–200	130–200	1.00–1.33	12–13


БЕЛОМОРСКОЕ МОРЕ
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ВОСТОЧНО-СИБИРСКОЕ МОРЕ
МОРЕ ЛАПТЕВЫХ
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Fig. 3. Distribution scheme of basic adverse degradation processes limiting the soil fertility in agricultural areas of Russia (State program of monitoring…, 1991). *Boundaries*: 1 – soil-ecological belts; 2 – soil-ecological zones; 3 – economic regions; 4 – State boundary. *The land category according to properties and processes limiting the soil fertility*: 5 – acidic, 6 – excessively wet, 7 – eroded, 8 – deflated, 9 – saline, 10 – saline solonetzic, 11 – alluvial (with different adverse properties), 12 – mountain territories predominated by erosion processes.

2a. The European taiga region is characterized by the temperate continental excessively humid climate, where the heat amount is rather low; the winter is severe and rich in snow. The agricultural areas are used for cultivating the early-maturing crops. Adaptive-landscape farming systems should be oriented to soil-agromeliorative measures including drainage, thermoregulation, decreasing the soil acidity, humus accumulation, nitrogen-phosphorus fertilization, flood regulation.

2b. The West-Siberian swampy-taiga region differs from that in Eastern Europe by a higher degree of the climate continentality and more severe winters. The areas under crops occupy small territories of podzolic and alluvial soils, where the summer quickly growing crops including cereals are cultivated.

The farming systems are the same like those used in European region. 2c. The East-Siberian frozen-taiga region is characterized by the sharply expressed continental climate (in some places it is semi-dried and semi-humid); the heat amount is rather low, the winters are very cold. The arable lands occupy small areas of alluvial, soddy-gley and pale soils. The summer quickly growing frost-resistant crops are cultivated. In the southern part of this region the peculiar natural post-thermokarsts – alases are used as agricultural areas.

2d. The Okhotsk-Kamchatka forest taiga region is situated within the zone of coastal humid climate, but the heat amount is insufficient, the winter is rich in snow and very cold. The arable lands occupy small areas on alluvial podzolic and soddy-gley soils. The farming systems are the same as those mentioned in the other regions.

The south-taiga zone of soddy-podzolic, brown forest, meadow, soddy-carbonate and soddy-gley soils includes 6 soil-agromeliorative regions, where the agriculture is sufficiently developed especially in European part of this zone.

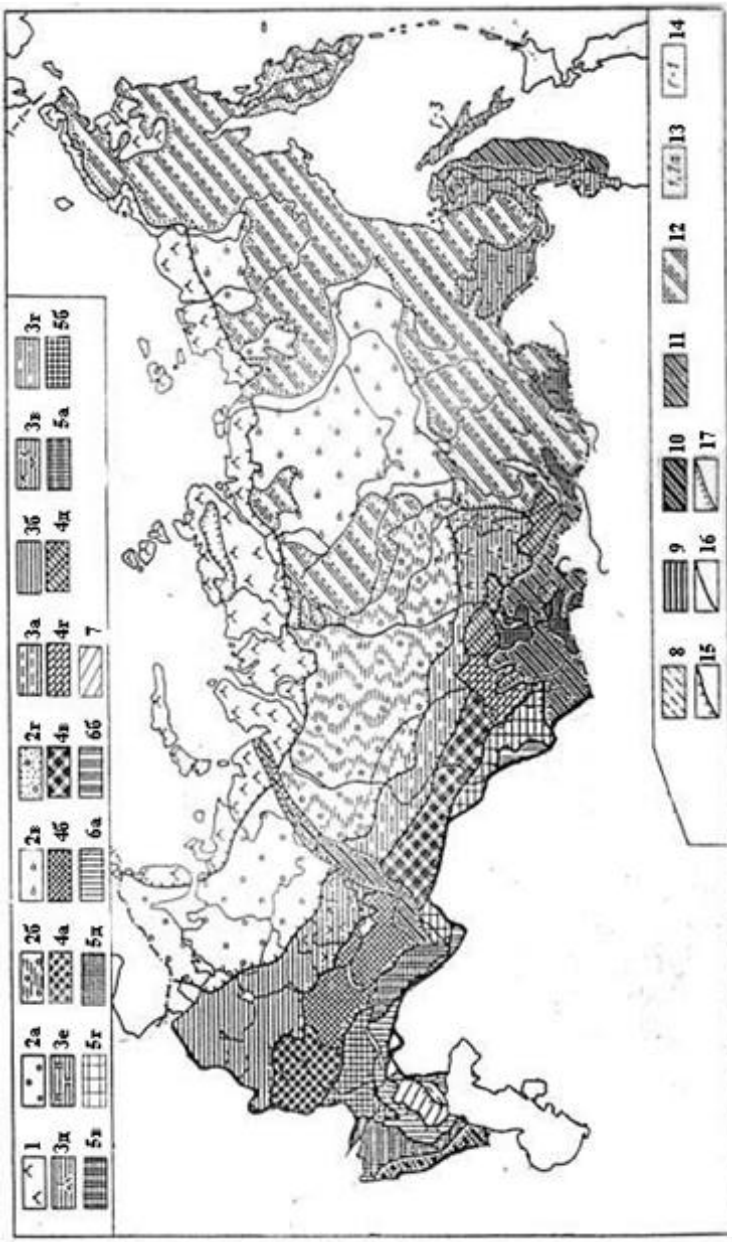

Fig.4. The complex soil-agromeliorative regionalization of Russia.

3a. The taiga-forest region in Western Russia (Kaliningrad region); it is situated within the zone of the coastal climate provided with the sufficient heat amount and soft winter. The arable lands cover the areas of soddy-podzolic (brown podzolic) drained, soddy-carbonate and alluvial soils and make up 0.1/% of the total area under crops in Russia. Among the cultivable crops are winter and summer cereals as well as the fodder crops. To advance the agricultural production, the measures are required to protect the soils against erosion and compaction. The wet soils need to be improved by regulating the water regime and applying the moldboard plowing at a different depth. Besides, it is very important to undertake measures oriented to accumulate the humus in soil.

3b. Central taiga-forest region; it is situated under conditions of the temperate continental climate with the sufficient heat amount and the cold snowy winter. The arable lands occupy soddy-podozlic soils and make up more than 10% of the total agricultural area in Russia. For agricultural purposes the fallows, cultivation of winter and summer cereals are used. With respect to soil amelioration such measures should be undertaken as the water regulation, plowing at a different depth as well as those oriented to decline the acidity, to accumulate the humus, to control against soil erosion and compaction.

3c. The Pre-Ural taiga-forest region; it is characterized by the continental moderately humid climate somewhat provided with the heat and temperate cold winters. The arable lands on soddy-podzolic soils occupy about 5% of the total area in this region; in the structure of areas under crops the cereals are dominant with using fallows to control predominantly against the weeds. As compared to the abovementioned region the same soil-improving measures are required and only the higher rates of organic fertilizers (10–12 t/ha/year) should be applied to accumulate the humus in soil.

3d. The West-Siberian taiga-forest region; it has the more continental climate with insufficient heat and cold winter rich in snow. The arable land occupies 1.5% of the total area on different-textured soddy-podzolic soils. In the structure of areas under crops the summer cereals are dominant occupying 2/3 of the total area in the region. Drainage, moldboard plowing, liming and dolomite application, humus accumulation (8–10 t/ha/year of organic fertilizers), the increased rates of min-

eral fertilizers (nitrogen, phosphorus, potassium), soil protection measures (erosion, compaction) are required to advance the agricultural production.

3e. The Middle-Siberian taiga-forest region; it occupies the territory between the West-Siberian taiga-forest and Ural-North-Siberian mountain regions and reveals the sharply expressed continental semi-humid climate with insufficient heat and very cold and severe winter. The agricultural land on soddy-podzolic soils is rather small (1%), predominated by growing of frost-resistant summer crops. Agromeliorative measures are identical to those recommended in the West-Siberian region but the dolomite application and the potassium fertilizers are not required to improve the soils.

3f. The Far East meadow-taiga region; it is situated within the zone of the coastal monsoon humid climate being provided with insufficient heat and the moderately cold winter in the northern part of the region. The agricultural lands occupy 1.5% including the third part of drained area under crops on meadow-brown, meadow-chernozem-like, meadow, soddy-gley and alluvial soils. The spring cereals as well as fodder crops are grown. As a peculiar feature is the cultivation of rice and soy-bean. To improve the insufficient amount of humus, 10-12 t/ha/years of organic fertilizers are required. Among the agromeliorative measures are drainage, water regulation, liming, mineral fertilization, etc.

The forest-steppe zone of gray forest soils and chernozems including 5 soil-agromeliorative regions.

4a. The Central-Chernozem forest-steppe region; the climate is temperate continental, semi-humid and humid providing with the heat towards the south; in the same direction the winter conditions are changed from the severe winter in the north to the soft winter in the south. The agricultural lands occupy the gray forest and meadow-chernozem soils, leached and typical chernozems. The area under crops accounts for 20% of the total territory in Russia. The major arable crops including fodder ones are cultivated there. The adaptive-landscape farming systems are oriented to the water accumulation, irrigation, plowing at a different depth, improvement of the humus deficiency (5–7 t/ha/year of organic fertilizers) and the phosphorus and

potassium deficit as well as the measures to control against the soil erosion and compaction.

4b. The Volga forest-steppe region; it is characterized by the continental semi-humid climate provided with the heat amount and the winter rich in snow. The arable area occupies 9% of the total territory in Russia including that used under irrigation. The soils reveal the humus deficit, they are provided with nitrogen and potassium but have an insufficient amount of phosphorus.

4c. The West-Siberian meadow-steppe region with meadow-chernozems including solonetzic gray forest soils and leaching chernozems. The climate is continental, semi-humid in the south and semi-dried in the south with the cold and rather snowy winter. The arable lands occupy about 10% of the total territory in the region including those used under irrigation and drainage. The spring cereals are predominantly grown (60% of the area under crops). The farming systems are the same as those used in the Volga region; only the measures to control against the solonetsization are required.

4d. The Pre-Altai forest-steppe region is characterized by the continental climate; it is semi-dried and humid in piedmonts; the winter is cold and snowy. The arable area occupies about 4% of the total territory on leached and typical chernozems as well as the gray forest soils. The cereals are grown occupying 2/3 of the area under crops. Adaptive-landscape farming systems are identical to those used in West-Siberian region but the contour subsoil tillage finds a broad application there. The phosphorus and humus deficit should be compensated (4–5 t/ha/year of the organic fertilizers).

4e. The Middle-Siberian forest-steppe region: the sharply expressed continental semi-dried climate being humid in piedmonts. The arable areas occupy about 2.5% of the total territory in the region, the soil cover of which is represented by gray forest, meadow-chernozic, soddy-carbonate soils and leached chernozems. The frost-resistant spring cereals are cultivated in ½ of the arable area. The farming systems are identical to those used in the West-Siberian region, but the humus deficiency should be compensated in a higher amount (6–7 t/ha/year of the organic fertilizers). The soils reveal a deficit of phosphorus and partially potassium. The adaptive-landscape farming systems should be soil-protective by nature.

The steppe zone of ordinary, southern, solonetzic, carbonate and meadow chernozems includes 5 regions.

5a. The Pre-Caucasian steppe region: the climate is temperate continental, semi-dried and semi-humid in piedmonts well provided with the heat, the winter is soft with a little amount of snow. The arable areas occupy approximately 8% of the total area including irrigated lands on ordinary, southern and carbonate chernozems. The spring and winter cereals are dominant (55%), the tilled crops occupy 24% of the arable area, fallows are used. The farming systems are directed to keep the soil moisture, to control against the water and wind erosion of soils by subsoil cultivation; to prevent the soil compaction, to increase the humus content (5–6 t/ha/year of the organic fertilizers), to compensate the phosphorus deficiency.

5b. Central steppe region is characterized by the temperate continental, dried and semi-dried climate with the temperate soft and temperate cold winter; it is sufficiently supplied with the heat. The area under crops occupies more than 8.5% of the total territory in the region being widely spread on southern and ordinary chernozems. The winter and spring cereals are predominated in the structure of areas under crops (to 60%); the tilled crops occupy 26% of the total area. The clean fallow is used to keep the soil moisture and to struggle with weeds (without herbicides). The adaptive-landscape farming systems are based upon the water and humus accumulation (6–7 t/ha/year of the organic fertilizers), the prevention of the water erosion and compensation of the phosphorus deficit.

5c. The Trans-Volga steppe region differs from Central region by a higher continentality degree, the dried and semi-dried climate with temperate cold and rather snowy winter. The arable areas on ordinary, southern chernozems and dark-chestnut soils occupy 6.7% of the total territory in the region. This region is considered as one of the important regions in respect of crop cultivation at the territory of 70%; hard wheat cultivars are mainly grown as the most suitable for the food industry. Perennial grasses, tilled crops and the clean fallow occupy the great area as well. The adaptive-landscape farming systems are used to accumulate and keep the soil moisture, to increase the humus content by application of the decomposed manure (3–5 t/ha/year), to protect the soil from the wind erosion and in some places from the water erosion,

to prevent the soil compaction as well as solonetzisation and salinization of soils.

5d. The West-Siberian steppe region is situated under conditions of the continental, dried and semi-dried climate with the cold snowy winter and the heat in the sufficient amount. The arable area on ordinary, southern and solonetzic chernozems is used for cultivation of cereals (75%), tilled crops and clean fallows. The adaptive-landscape farming systems are identical to those applied in the Trans-Volga region.

5e. The Middle-and East-Siberian steppe region is characterized by the continental, strongly dried and semi-dried climate with the cold snowy winter and insufficient heat amount. The arable lands occupy insignificant areas (2.6%) on ordinary, southern and meadow chernozems as well as on the dark-chestnut soils. The spring cereals are widely spread (more than 60%). The farming systems are oriented to accumulate the humus, to protect soils and to keep the sufficient balance of nutrient elements due to the increased NPK rates.

The dry-steppe zone of chestnut, solonetzic chestnut and meadow-chestnut soils includes two regions.

6a. The East-European dry-steppe region: the strongly expressed continental and very dried climate with the cold and moderately snowy winter; the heat amount is rather sufficient in this region. This is an agricultural region because the arable lands including irrigated ones occupy 13% of the total territory, being predominantly cultivated by spring and winter cereals (70%) and tilled crops; about 10% of these lands are used as clean fallows. The adaptive-landscape farming systems are based upon the intensive moisture accumulation and irrigation; the measures to prevent the solonetzisation, salinization and compaction of soils are required as well as to prevent the humus deficiency (4–5 t/ha/year) and to increase the content of phosphorus and nitrogen in soil.

6b. The West-Siberian dry steppe region with the continental, very dried climate; the winter is cold and snowy; the region is moderately supplied with the heat. The arable lands occupy approximately 1% of the total territory being situated on chestnut, chestnut solonetzic and meadow soils. The spring cereals make up 70%, tilled crops – 3%

and 9–10% of clean fallows. The farming systems are the same as in the abovementioned regions.

The semi-desert zone of light-chestnut, chestnut solonetzic and meadow soils is in coincidence with the territory of the South-European semi-desert soil-agromeliorative region characterizing by the continental dry and semi-dry climate with the moderately cold winter and the sufficient amount of heat. The arable areas including irrigated ones account for 0.5% being cultivated by spring cereals, vegetables and water-melons. The regular irrigation, soil protection measures and those to prevent the soil compaction and salinization are required; the soils need to be improved by organic (4 t/ha/year), phosphorous and nitrogen fertilization.

The desert zone of brown, brown solonetzic, gray-brown and sandy desert soils is found to be in coincidence with the Pre-Caspian soil-agromeliorative region characterizing by the continental dry climate with the soft or moderately cold winter and the sufficient heat amount. The arable lands on brown and brown solonetzic soils under irrigation occupy 0.1% of the total area under crops. Among the cultivated crops the vegetables, melons and gourds, fruit plantations are dominant; the cereals include the spring crops of middle-and late maturity. There is an experience in growing such technical crops as cotton. The farming systems are identical to those used in the South-European region.

The subtropical humid-forest zone of zheltozems, alluvial, alluvial-swampy and meadow soils under conditions of the temperate continental and excessively humid climate with the soft snowless winter and a higher supply with the heat amount. The arable lands occupy the drained territory on zheltozems accounting for 0.06% of the total area under crops. The farming systems are based upon the water regulation, decrease in the soil acidity and the humus accumulation (10-12 t/ha/year); the measures to prevent the soil erosion and compaction are required.

Such a comprehensive analysis of the natural potential in regions of Russia may be useful for a scenario of possible global climate warming capable to exert the influence on the farming systems, agrotechnologies and the rational allocation of areas under crops.

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