Application of Different Indicators for Assessment of Dynamic Soil Erosion Rates within the Russian Plain during Recent Decades

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The southern half of the Russian Plain comprises the southern part of the forest, forest–steppe and steppe landscape zones, and it is one of the major agricultural regions in the Russian Federation. It is characterized by a temperate continental climate with a mean annual precipitation of 400–600 mm, one third of which falls during the 5 to 6 months long cold season. The precipitation and moisture availability gradually decrease in the south–southeastern direction. In the central part of the Russian Plain, around the city of Moscow, the annual precipitation is in the range of 600–700 mm while the annual precipitation near the northern coast of the Caspian Sea on the southwest of the Russian Plain is less than 200 mm. The relief of the southern half of the Russian Plain is composed of a combination of uplands and lowlands strongly dissected by fluvial networks down to bedrock and overlain by Pleistocene loess of varying thicknesses. Loess and moraine are the parent material for local soils in the central and southern parts and in the northern part of the area, respectively. Soils types change from the north to the south, from the podzol and grey forest soils to some types of chernozem in the middle, and the chestnut soils in the south of the steppe zone.

Soil erosion during snow-melt events and rainstorms occurs mostly on arable lands of the Russian Plain. Mean annual soil losses from cultivated lands are estimated by soil erosion models to vary from 1 to 3 t ha^{-1} within the lowlands to 6 to 8 t ha^{-1} in the uplands, with the maximum (10 t ha^{-1}) predicted near the Caucasus Mountains in the Stavropolskiy Krai (Sidorchuk et al., 2006). The intensity of gully erosion has been relatively low during the last two decades; however, there were a few stages during the period of the intensification of land cultivation when it was high, in particular in the uplands.

The collapse of the Soviet Union in 1991 caused a serious crisis in agriculture. Part of the arable lands were abandoned and some changes in crop rotations occurred. In addition, global warming has led to changes in the proportion of soil losses from cultivated lands during snow-melt events or rain storms. Different indicators can be used for evaluating the trends in soil erosion rates, as there is a lack of monitoring data. Indicators can be split into two groups. The first group includes hydro-meteorological and agricultural parameters, namely: recurrency of extreme rains during the warm part of the year, maximum water discharges and duration of spring floods, type of crops and/or crop rotations, and area of arable lands. The second group includes characteristics of gully retreat, and sediment deposition rate dynamics in the different sediment sinks along pathways from cultivated slopes to the river channel.

Four transects were selected within different landscape zones of the southern half of the Russian Plain for evaluation of contemporary trends of erosion rates on the arable lands, based on application of different indicators (Figure 1A). Each transect crossed both upland and lowland areas of the different landscape zones, and was contained within the administrative region of Russia. Typical soil types and crop rotations were represented within each transect. Maximum reduction of the agricultural land area was observed in 2003 (Figure 1B). Later on the

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area of agricultural land became stable or even slightly increased to 2015.

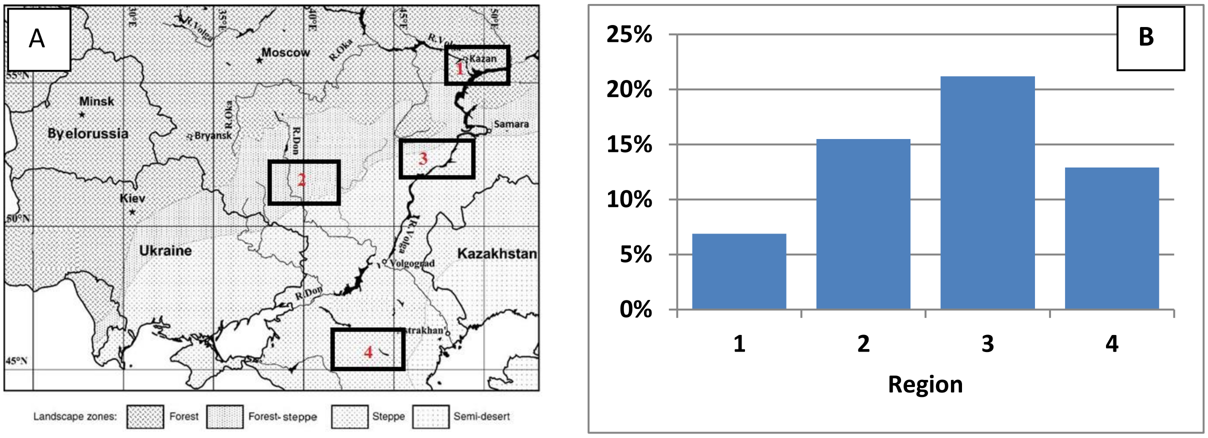

Figure 1. Map of the southern part of the Russian Plain and location of transects (regions) in the different landscape zones (A), and reduction of agricultural land area from 2003 to 1990 (area of agricultural lands in 1990 was 100%) (B). Legend: Region/transect: 1-Republic Tatarstan; 2-Voronezh region; 3-Saratov region; 4–Stavropol krai.

Despite some changes in crop rotations since the USSR collapse, the cropping factor did not vary considerably in all studied regions (Table 1). Hence it is very likely that the anthropogenic factors have limited influence on the possible variations in soil erosion rates.

Table 1. USLE cropping (C) factor during last 25 years for four transect regions.

	Transect/region	Cropping factor for the rainfall period			Cropping factor for the snow-melt period		
		mean	σ	C_v %	mean	σ	C_v %
1	Republic of Tatarstan	0.34	0.01	3.25	0.79	0.02	2.97
2	Voronezh region	0.46	0.01	1.76	0.86	0.01	1.59
3	Saratov region	0.40	0.02	4.18	0.85	0.03	4.00
4	Stavropol krai	0.46	0.01	1.25	0.75	0.03	3.82

Influence of climate change was assessed based on evaluation of some trends of hydro-meteorological characteristics collected from meteorological and gauging stations located within the small river watersheds. In addition, results of evaluation of sedimentation rates in different sediment sinks for two time intervals (1963-1986 and 1986-2015, applying bomb-derived and Chernobyl-derived ^{137}Cs techniques for dating) were used for determination of erosion rate dynamics.

References

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