

EFFECTS OF SOIL EROSION ON AGRICULTURAL LAND: A CURRENT GLOBAL AND NATIONAL ANALYSIS

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Abstract

Loss of soil through erosion on agricultural land is a widespread problem, reducing primarily the productivity of all natural ecosystems as well as agricultural ecosystems, forests and pastures. In parallel with population growth, soil erosion, water availability, climate change, biodiversity loss are considered as the main environmental issues around the world. Although soil erosion along the geological era occurred at a slow pace in natural ecosystems, the cumulative impact on soil quality over billions of years has been significant. However, even soil erosion with low annual rates over the years can lead to the displacement of enormous quantities of soil.

Soil erosion has been recognized as a major problem that threatens the sustainability of agriculture for a long time, and the magnitude of the problem can be properly assessed. The direct effects of erosion are not limited only to damage to agriculture. The sediment produced by erosion also pollutes water flows with sediments and nutrients, thereby reducing water quality.

Key words: soil erosion, water erosion, land degradation, agriculture

Population pressure on lands has led to increased erosion, so research on soil erosion processes presents a great deal of practical interest. Soil erosion is one of the most aggressive and disastrous phenomena of the Earth's, and the fight against this scourge is becoming heavier and costly. In most of the papers, erosion processes are studied not as independent phenomena but in connection with the whole complex of elements and natural factors in the middle of which they are carried out, considering not only the way of manifestation of these processes but also the evolution in time. This is natural and necessary because, on the one hand, the erosion process has a close interdependence with other phenomena of nature.

Worldwide research places special attention on improving degraded lands for their introduction into the productive cycle, because soil erosion has gained large proportions in the 20th century, destroying large areas of land. Of the processes that affect the soil quality, erosion is in fact of greatest interest, both in terms of the damage caused and the affected areas (Ailincăi C. *et al*, 2011; Boardman J. *et al*, 2006; Dautrebande S. and Colard F., 2003; Flanagan D.C, 2009; Jha M.K, 2010; Moțoc M., 2002; Pleșa I. and Cîmpeanu S., 2001; Savu P. and Bucur D., 2000; Sohier C. and

Degre A, 2010; Toy T.J *et al*, 2000; Van der Knijff M. *et al*, 2000).

According to FAO studies, currently about 80% of the world's agricultural area is affected by erosion degradation, from a moderate degree to a severe degree, while 10% of light erosion. Erosion on agricultural land ranges between 0.5 and 400t/ha/year, with an average value of about 30t/ha/year. Over the last 40 years, about 30% of the world's agricultural lands has become unproductive and a large proportion of them have been abandoned.

The vastness of this phenomenon on soil quality worldwide has led to the adoption of the Paris Convention, which was signed in 1994 by 87 states, with the principle of removing the degradation of soils caused by exaggerated grazing, irrational recovery of agricultural lands, deforestation, irrigations that are inadequate and at the same time intensified by the variable climatic conditions; all this jeopardizes the food security of the population at global level, namely from around 100 countries threatened by this phenomenon.

The UN General Assembly held in 2015 to celebrate the International Year of Soils says that land degradation as one of the most important environmental issues. Over the last 40 years, about 1/3 of the world's arable land has been excessively

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degraded due to erosion as the population has risen.

MATERIAL AND METHOD

In order to carry out the study, we collected data from the study of the topographical maps (sc. 1:50 000 and 1: 100 000) data on global land use provided online by FAO reports GLASOD, reports and research undertaken by the ELD - The Economics of Land Degradation, by the United Nations Environment Program.

For the situation in Romania, the data collected from the study of the topographical maps (sc 1: 50 000 and 1: 100 000) and the soils (1: 200 000), data on the evolution of agricultural use provided by the Ministry of Agriculture and Rural Development, from the Office for Pedological and Agrochemical Studies and a current situation of

land degraded by the National Agency for Land Improvements. Also useful information was extracted from the Institute of Statistics.

The data and information obtained show a concrete and current situation on agricultural land affected by erosion.

RESULTS AND DISCUSSIONS

According to GLASOD studies, about 75 billion tonnes of fertile soil is estimated to be lost annually (*table 1*). This is due to the fact that the population is constantly growing and especially because the lands are often irrationally cultivated (*table 2*). The highest rates of erosion in agricultural ecosystems are in Africa, Asia and South America, with an average of 3-40 tonnes/ha/year.

Table 1

Types and degrees of soil degradation worldwide (in million ha)

Types of degradation	Degradation level				Total
	Weak	Moderate	Strong	Excessive	
Water erosion	18.9	64.7	9.2	0.0	92.8
Land deformation	2.5	16.3	0.6	2.4	21.8
TOTAL	21.4	81	9.8	2.4	114.6
Wind erosion	3.2	38.2	0.0	0.7	42.1
Land deformation	0.0	0.0	0.0	0.0	0.0
Wind farms	0.0	0.0	0.0	0.0	0.0
TOTAL	3.2	38.2	0.0	0.7	42.1

Table 2

Global estimates of soil degradation on agricultural land (Scherr 1999) - (in million ha)

Area	Total Agricultural	Degraded lands	%
Africa	187	121	56
Central America	38	28	74
North America	236	63	26
South America	142	64	45
Asia	536	206	38
Oceania	49	8	16
Europe	287	72	25
Total	1475	562	38

The average specific erosion worldwide is 134 t/km².year, with the continental distinction being: Australia - 43t/km², Africa - 82t/km², North and Central America - 113t/km², South America - 148t/km² and Asia - 208 t/km². (Băloui V. et al, 1986). A 1992 UN report shows that approximately 15.5% of the world's agricultural land is heavily degraded and 51.7% is moderately degraded.

Erosion is triggered, in particular and due to the anthropogenic interventions. In some states, forests have been deforested on very significant areas, and this antropoc intervention has led to a degree of accelerated erosion. An example is Ethiopia, a country where forests accounted for about 50% of the country's total area at the

beginning of the 20th century, but in 1995 the forest area was only 3%.

China has been assessed in the past as the global leader of agriculture, but over time the degradation of agricultural land has been sharply accentuated. According to official statistics, it is concluded that in the last three decades about 15 million hectares of arable land has changed its use. In 1992, a surface of 667 thousand hectares of arable destination was removed from the agricultural circuit.

Because of the intensive use of agricultural practices, China now has more than one third lands cultivated by poor quality, many areas being affected by soil erosion.

In poorer or developing countries, soil erosion is viewed as a rather delicate problem especially for owners who have small farms where they tend to set up crops in distant rows, such as corn and beans, especially because, as a rule, perennial crops are very successive to erosion. For example, in the Sierra Region of Ecuador, about 60% of the cultivated agricultural area was abandoned due to excessive land degradation caused by erosion and inappropriate agricultural practices. Similar problems are also found in the Amazonian region of South America, especially in areas where massive deforestation, has taken place to set up crops for sugar cane culture. Also on the entire African continent, erosion has resulted in an average decline in annual agricultural production of 8.2%.

Lal, Stewart and Wen, soil science specialists reported that 6.6 billion tons of soil are lost annually in India, and 5.5 billion tonnes are lost annually in China. According to a study by the Central Institute for Water Conservation Research and Training in Dehradun, India reported in 2010 that the average soil erosion loss rate is 16.4 tonnes per hectare/year with a total annual loss of 5.334 billion tons. A three-year study by researchers associated with the Chinese Ministry of Water Resources, the Chinese Academy of Sciences and the Chinese Academy of Engineering reported in 2009 that all counties in China suffered significant losses of soil and water. This study showed that if the country's current soil rate continues over the next 50 years, food production will decrease by 40%.

The UN General Assembly in 2015 said Africa is particularly vulnerable to land degradation being the world's most affected area. This continent annually loses about 280 million tons of grain crops, from about 105 million hectares of farmland.

This could be prevented if soil erosion is properly managed. Rwanda being a state largely situated on steep slopes, especially the northern part, suffers from damage caused by soil erosion, especially caused by torrential rains or abundant rainfall that washed the fertile soil over time. This form of degradation has had particular repercussions on the population, as agricultural output has been severely affected, pushing the state to poverty.

The lowest erosion rates on agricultural land are in the United States and Europe, with an average of 10-15 tonnes/ha/year. In the United States, the erosion rate has fallen from 16.4 t/ha/year in 1982 to 10.8 t/ha/year.

Most reports on the global state of soil degradation by erosion concern the European region as being less disturbed than the situation in other regions. According to an estimate of ISRIC (Oldeman L.R., 1991), the cumulative average loss of productivity during the period after World War II due to human-induced soil degradation was estimated at 7.9%, while in Africa was 25% and in central America was 36.8%.

A recent report (Jones *et al*, 2011) estimated that in the years 1990, 105 million hectares, or 16% of Europe's total area (except Russia), were caused by water erosion. In Russia, the area affected by erosion is about 51 million hectares, 26% of the agricultural land area and about 3.5% of the total lands area. In Ukraine, the area affected by erosion accounts for about one third of all agricultural land or 14.4 million hectares. Moldova also has an area of about 840 thousand hectares, or 33.6% of the total lands area.

A Council of Europe report using revised GLASOD data (Oldeman L.R et al, 1994) provides an overview of the extent of soil degradation. Some of the findings are presented in Table 3, but the figures presented are only an approximation of the area affected by soil degradation.

Table 3

Types and degrees of soil degradation in Europe (Area in million ha)

Types of degradation	Degradation level				Total
	Weak	Moderate	Strong	Excessive	
Water erosion	301.2	454.5	161.2	3.8	920.7
Land deformation	42.0	72.2	56.0	2.8	173.0
TOTAL	343.2	526.7	217.2	6.6	1.093.7
Wind erosion	230.5	213.5	9.4	0.9	454.3
Land deformation	38.1	30.0	14.4	0.0	82.5
Wind farms	0.0	10.1	0.5	1.0	11.6
TOTAL	268.6	253.6	24.3	1.9	548.4

However, Table 3 shows the importance of water erosion in Europe for the affected area. The most dominant effect is the loss of vegetal soil, which is not often visible, but yet it has very harmful potential. Physical factors such as

climate, topography and soil characteristics are important in the soil erosion process. In part, this explains the difference between the serious problem of soil erosion from Iceland, but the much less severe erosion in Scandinavia, where the

climate is less severe and the soils are less erodible (Fournier, 1972).

The diversity of relief conditions, climate, soil, vegetation and socio-economic conditions in the country's perimeter, make erosion acquire shapes and steps of significant intensity, from one region to another. In Romania, out of the total area of agricultural land, about half are in the slope, with different inclinations, and those characterized by slopes higher than 5% being favorable to erosion.

From the point of view of erosion, the colinar areas of Moldova, Transylvania, Dobrogea are of interest. The lands most affected by erosion are found in the Moldavian Plateau, Getic, Transylvanian and Someșan Plateau, these lands being defined by a vigorously fragmented relief with variations of clayey and sandy rocks, erodable soils, where a significant feature is designated by surface drains resulting from torrential rains, which occur between April and September, and also melting snow. The agricultural area in our country, prone to erosion, is about 6.4 million hectares, out of which 3.6 million hectares are arable. The largest areas of arable land affected by erosion are in the counties of Botosani, Vaslui, Cluj, Iasi and Salaj.

Agricultural lands with a strong erodibility are also encountered in the Carpathian curvature sector - the hydrographic basins of Slănic-Buzău, Bercăi, Sărățel and Pârcșor. In these areas, the irrational deforestation of forests and exaggerated

grazing, in the case of fractional relief and fragile soils, participated in the erosion process and also in the production of other degradation forms.

The hydrographic basins of Arges, Jiu and Olt are defined by a solid fragmentary relief, with sandy and stony rocks, and the summer torrential rains intensify the erosion process.

Soil erosion has a negative influence on the progress of the territory, especially from an economic point of view. Exemplary is the Vrancea county, where due to the irrational use, of the sloping land, erosion has grown at a rapid pace, with large areas currently being affected by excessive erosion, and due to this foundation, many lands have been removed from the economic circuit.

Of the total agricultural area of Romania, 14,630 ha, about half, is subject to erosion degradation, of multiple degrees. Hence, 3.20 million ha, are land with an inappropriate erosion, and unless consistent action is taken, the degree can be amplified, 3.0 million ha have moderate and strong erosion, and 0.89 ha have excessive erosion.

Erosion through water is the most common form, hence causing the emergence on agricultural lands, deep erosion formation but also the aggravation of torrential character. The analysis on the situation of degraded agricultural land (according to INCDPAM-ICPA Bucharest - Table 5) notes that agricultural land is affected by this form of erosion, 45% of the total agricultural area.

Tabel 4

The situation of erosion – affected lands in Romania on cultivated lands and pastures

Land type	Agricultural lands		From which			
			Cultivated lands		Pastures	
	Mii ha	%	Mii ha	%	Mii ha	%
weakly eroded lands with risk of water erosion	3 780	25.3	1 365	13.0	2 415	54.3
with inappropriate erosion	2 705	18.1	1 155	11.0	1.550	34.9
weak eroded	1 075	7.2	210	2.0	865	19.4
affected by water erosion	2 990	20.0	1 890	18.0	1 100	24.7
moderate - strong	2 048	13.7	1.302	12.4	746	16.8
very strong - excessive	942	6.3	588	5,6	354	7.9
affected by wind erosion	336	1.6	199	1.9	37	0.9
weak	218	0.8	105	1.0	13	0.3
moderate - strong	29	0.2	20	0.2	9	0.2
very strong - excessive	89	0.6	74	0.7	15	0.4
TOTAL	7 106	46.9	3 454	32.9	3552	79.9

According to the studies, it is appreciated that the degree of erosion of soils is acceptable within certain limits, depending on the geographical area, the starting value ranging from

0.5t/ha to 37.5t/ha per year, the weighted average of the country being of 16.28t/ha/year. The maximum acceptable extremity, for the soil erosion process is 5-6 t/ha. It has been found that

areas with high erosion are mainly in the hills areas of Moldova, Transylvania and the south of the country.

A particular concentration was adapted to the differentiation of sediment sources in relation to the contribution of the main uses of the land and erosion to the formation of total erosion (*table 4*). Annually, across the country, agricultural lands loses significant amounts of soil (approximately

126 million tonnes of eroded solid material), the total erosion in relation to the type of erosion is

shown in *table 5*.

Table 5

Total erosion in relation to land use (Moțoc M. 1983)

Land use	Total erosion			
	Mil/t/an	%		
Arable	28.8	26.2	24.7	22.3
Pastures	45.0	42.2	39.6	35.7
Vinyards	1.7	1.6	1.5	1.2
Orchards	2.1	2.0	1.8	1.7
Non-productive	298	28.0	26.4	23.6
Total – agricultural fund	375,6	100.0	-	-
Forest fund	6.7	-	6.0	5.3
TOTAL	6.7	-	100.0	-
Erosion in river banks and cities	12.7	-	-	10.2
TOTAL	395	-	-	100.0

Table 6

Differentiation of total erosion on erosion forms (Moțoc M., 1983)

Erosion form	Total erosion		
	Mil.t/year	%	
Surface erosion	61.8	54.5	49.0
Depth erosion	29.8	26.4	23.6
Landslides	15.0	13.1	11.9
Depth erosion and landslides in forest fund	6.7	6.0	5.3
TOTAL	113.3	100.0	-
Erosion in river banks and cities	12.7	-	10.2
TOTAL	126.0	-	100.0

CONCLUSIONS

A total inadequate exploitation of land use but also due to natural phenomena, and in the past, absence of adequate measures to prevent and combat degradation processes, the erosion process has now become global problem.

In some countries around the world, the annual erosion rate is rising significantly, with the main consequence being the sharp decrease in agricultural production and the accelerated of land degradation by erosion.

The depth of the degradation of land quality in recent years, both in Romania and worldwide, defined by the occurrence of natural phenomena, often supported by anthropogenic intervention in the local landscape, is important to send an alarm signal to develop effective measures and works to reduce the rate of soil degradation. A methodical observation of the evolution of soil properties is useful and necessary, especially due to the consequences of the anthropogenic factor.

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