SOIL EROSION AND CONSERVATION IN ROMANIA - SOME FIGURES, FACTS AND ITS IMPACT ON ENVIRONMENT

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Abstract
Being a common and finite resource, soil - as a natural and very complex ecosystem, is essential to human society. In several regions of Europe, including Romania too, soil resources are degraded due to different causes, or, sometimes, irreversibly lost, mainly due to erosion, decline in organic matter or contamination. As regard to soil erosion only, in Romania, about 42% of the total agricultural lands are affected by water erosion in different forms and intensities.
Soil degradation has negative impacts on other areas also, not only in-site but also off-site, areas which are also considered of common interest for the people (e.g. air and water quality, biodiversity and climate change). Costs to restore such a damages and environmental quality in general may be very high and thus preferable to be avoided.
To maintain and/or improve a good quality of the soils for a long period of time, there needed to be implemented in Romania , as much as possible, some agri-environmental schemes, according to the current EU models and policies, in particular, through the Common Agricultural Policy (CAP).
*The paper briefly presents and analyzes such agri-environmental schemes developed for the agricultural lands from the hilly areas in Romania that is very affected by water erosion and landslides – the Curvature zone of Sub-Carpathians. The schemes, developed within the Research Station for Soil Erosion and Conservation Aldeni-Buzau, which belongs to the University of Agricultural Sciences in Bucharest, is based on friendly agricultural practices to be implemented on agricultural lands located on slopes. Also, the new conceptual European model, known as **D**riving Forces-**P**ressures-**S**tate-**I**mpacts-**R**esponces (**DPSIR**), adapted for the soil erosion impact assesment on environment, will be here presented, in order to be promoted and used on a large scale in Romania as well.*

Keywords: soil erosion, sediments, impact, environment, DPSIR model

1. SOME DATA CONCERNING SOIL AND LAND DEGRADED AREAS IN ROMANIA

Soil and land degradation, in the broad sense of the word, is generated by action of several factors, the anthropogenic ones prevailing. Thus, on more than about 12 million hectares out of the 15 million hectares of agricultural lands, soils are subject to the influence of one or several factors of degradation, such as: erosion, increasing of the salt contents due to raising of the ground water level, compaction, acidizing and chemical pollution (pesticides, heavy metals, fluorides, oil, etc.) [4].
In Romania, about 43% from the total agricultural area is situated on the slopes more than 5%. Average slope of the Romanian agricultural lands is about 9.2%, which means that 35% from the total arable land is situated on the slopes greater than 5%. Due to their characteristic conditions of relief, lytology, pedoclimatics and vegetation, it can be said that the main Romanian agriculture problem in the hilly areas is soil erosion, as well as the draught in the plain regions. Almost 5.3 million hectares of agricultural land are vulnerable to surface and depth erosion and to landslides. Water erosion is considerable on about 3.5 million hectares of this area so that in certain regions situated in Subcarpanthians Curvature area (Vrancea and Buzau Counties) it reaches about 30-45 tons/ha/year, as against to the regenerative capacity of the soil, which is about 3 - 6 tons/ha/year, only [3].
Soil loss is about 150 million tons annually, including about 1.5 million tons of humus, respectively 0.4 - 0.5 million tons nitrogen, a large amount of phosphorus, potassium and other different nutritive elements.

Although the arable land is located on gentler slopes, that is a major source for soil loss because the high ratio of the row-crops (corn, dry beans, sunflower, and potatoes) has determined a high rate of the erosion processes. The non-adequate management of the pastures had an unfavorable influence, too. For example, an area more than 55% out of the about 4.8 million hectares of pastures and meadows is affected by erosion and landslides because of the severe slope, mainly, (about 75% of pastures and meadows are situated on slope greater than 5% and an area estimated at 35% from the total area covered by pastures and meadow is situated on slope greater than 20%.).

The affected areas by water erosion, which include the agricultural lands, forests and the unproductive areas on slopes, are as follows: slight erosion - 46.3%; moderate and high erosion - 41.5% and severe - excessive erosion - 12.2% [4].

Concerning the agricultural eroded lands only, it has been found that the slight-severe erosion class is about 43% of the whole area, according to data presented in Table 1 [4].

Table 1 Agricultural eroded lands by the erosion rate in Romania (after M. Motoc et al., 1992)

No.	Class of the erosion intensity	Variation limits of the erosion intensity t/ha/year	Mean value t/ha/year	Percentage from the agricultural lands areas (%)
1	Non-appreciable erosion	less 1	0.5	57.4
2	Slight erosion	2 - 8	5.0	3.0
3	Moderate erosion	9 - 16	12.0	19.0
4	High erosion	17 - 30	23.0	18.0
5	Severe erosion	31 - 45	37.5	2.6

With respect to the sediment sources in making-up of total erosion in Romania, in 1984, M. Motoc paid a special attention in his researches carried out along the country, with some of the results presented below in Table 2.

Table 2 Total erosion by types of water erosion (after M. Motoc et al., 1992)

No.	Type of erosion	Total erosion	
		million tons / year	% from total erosion
1	Surface erosion	61.8	49.0
2	Gully erosion	29.8	23.6
3	Landslides	15.0	11.9
4	Gully erosion on woodland	6.7	5.3
5	Riverbanks and localities erosion	12.7	10.2
	GENERAL TOTAL	126.0	100.0

Data presented in Table 2 show that surface and gully erosion are the most important contributing types of erosion. A mention must be made here, that for landslides, river banks and localities erosion highly reliable data are lacking as to magnitude and distribution on a national scale. Such data were local available and for a larger scale they are approximately.

Landslides, gully erosion and surface erosion contribute to the decreasing of cropland areas. Both, landslides and gullies, are decreasing the agricultural lands by 5,000 ha/year.

Up today, on about 2,280 million hectares there have been performed soil erosion woks; unfortunately many of these works are now damaged, as a result mainly of land ploughing from up-hill to the down-hill and the lack of maintenance works.

Thus, some friendly agricultural practices developed for the agricultural lands from the hilly areas in Romania, which are based on the long term results obtained from the soil erosion and conservation research stations in the country, are really needed to be

implemented as soon as possible on the agricultural lands located on slopes.

2. SOME DATA CONCERNING EROSION RATES ON DIFFERENT SLOPES AND LAND COVER

Long-time field measurements, since 1970, conducted at the Soil Erosion and Conservation Aldeni Research Station - Buzau (Subcarpanthians Curvature zone) on the standard runoff plots of 40 m^2 and 100 m^2 respectively, (see Figure 1), with loamy textured chernozems and mean annually precipitation of about 450 mm, out of which about 350 mm are fallen during the vegetation period, April-September, illustrate the influence of slope and crops cover on soil loss, as reported in Table 3, as the best applied conservation measures [3].

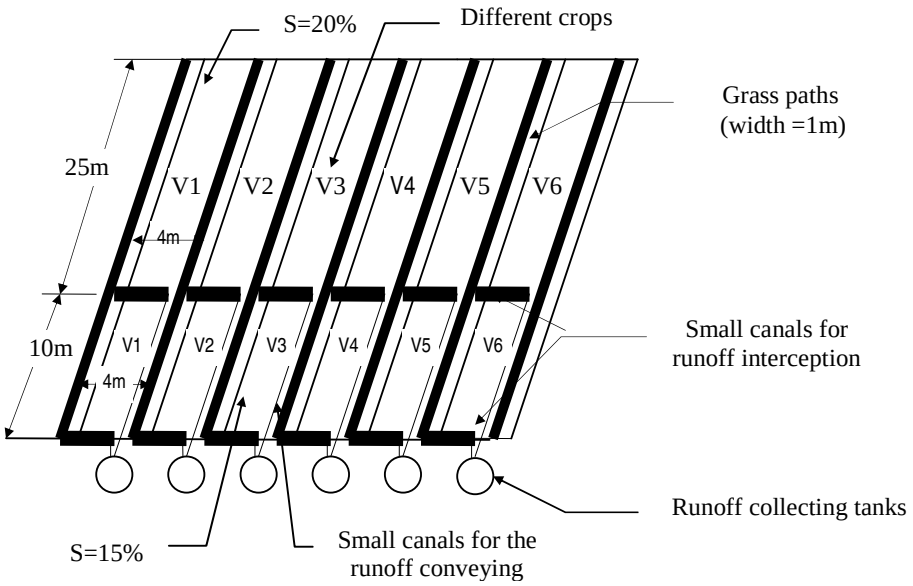

Figure 1 Sketch of the runoff plots at the Station for Soil Erosion and Conservation Aldeni / Buzau

Table 3 Average annual soil loss, in tons/ha, from the Aldeni/Buzau Runoff plots, between 1995-2010 (after S. Mircea, A. Radu, M. Musat, 2010)

Crop / Slope	Bare soil	Corn	Winter wheat	Perennial grass crop	Bean	Sugar beet	Buffer strip
S=15%	40.95	13.1	2.9	0.2	10.7	4.3	1.3
S=20%	97.9	32.9	3.8	0.3	16.6	9.2	6.3

Data presented in Table 3 show the big importance of a very good land cover in reducing erosion, obviously, the most recommended crops being those with a big density, compared with row crops, especially maize. Also, there is obviously a big difference between the soil loss rates under the same crop, occurred on the gentle slopes compared with the slopes that are very steep for arable purpose, even from simple to double.

As regard to the concrete situation in the field, due to several reasons (natural and socio-economic) but mainly due to the lack of an inadequate antierosion strategy, it can be said that very often soil loss is exacerbated by attempting to farm slopes that are too steep, and especially cultivating up-and-down hill

(see figure 2), as well as continuous use of the land for the same crop without rotation or inadequate use of fertilizers and organic manures. Thus, some erosion control measures, as presented roughly in the next chapter, must be adopted urgently in this situation, according to EU Common Agricultural Policy (CAP). Soil erosion control is being an important part of sustainable rural development of the hilly regions of the country, known as being poorer, where some incentives for farmers are really needed.

3. METHODS FOR SOIL EROSION CONTROL IN ROMANIA

As it is well known, the aim of soil conservation works is to obtain the maximum sustained level of production from a given area of land located on slope by maintaining soil loss below a threshold level which, theoretically, permits the natural rate of soil formation to keep pace with the rate of soil erosion. In the long term, erosion must be controlled to prevent land deteriorating in quality until it has to be abandoned and cannot be reclaimed, thereby limiting options for future use. Much money will be spent attempting to reclaim land where soil degradation has become virtually irreversible but the low productivity of the land means that the investment is highly questionable since it can never be repaired. Since erosion is a natural process, it cannot be prevented but it can be reduced to a maximum acceptable rate or soil loss tolerance.

The relevance of conservation measures to a farming system depends in part on how farmers and other stakeholders perceive the erosion problem and its consequences. Unfortunately, most farmers are not enough aware of the erosion problem and its effects both on- and especially off-site. A deep analysis concerning causes-effects of the erosion process in many parts of the country that are severe affected by water erosion should be carried out immediately, based on the experience of the new conceptual European model DPSIR (**D**riving Forces-Pressures-**S**tate-**I**mpacts-**R**esponses), as is presented later on in this paper.

There were used in Romania on a large scale, and there are still maintaining, the traditional conservation measures on the agricultural lands, such as: agronomic measures, soil management as well as mechanical methods. Agronomic measures utilize the role of vegetation to protect soil against erosion, soil management is concerned with ways of preparing the soil to promote plant growth and improve its structure so that it becomes more resistant to erosion, while mechanical or physical/structural measures depend upon modifying the surface topography to control the water flow. Among these measures are mentioned the following: contouring, strip-cropping, buffer strip-cropping, perennial grasses in the crop rotation system, agroterrasing on cropland, wine and fruit plantation terraces, gully control structures and artificial re-vegetation of the denuded fields by shrubs and trees. Generally, preference is always given to agronomic measures, these being less expensive and deal directly with reducing raindrop impact, increasing infiltration, reducing runoff volume and decreasing wind and water velocities. They are also more easily fitted into an existing farming system. Mechanical measures are largely ineffective on their own because they cannot prevent the detachment of soil particles. Their main role is in supplementing agronomic measures, being used to control the flow of any excess water. Many mechanical works are costly to install and maintain, and thus less recommended to be applied compared with the agronomic ones.

4. SOME ASPECTS CONCERNING DPSIR CONCEPTUAL MODEL FOR SOIL EROSION ANALYSIS

In a broad sense, the conceptual model DPSIR (Driving Forces-Pressures-State-Impacts-Responses) is a detailed analysis causes-effects of a natural process that has

any kind of impact on environment, following a ring from driving forces (activities) to pressures, changes on environment state, impact and establishment of responses (according to EEA, 2000, based on the first approach of Organization for Economic Co-operation and Development – OECD, 1993) [1]. Practically, DPSIR analysis starts from the idea that all socio-economic activities and society behavior in general, affects more or less the quality of environment. The DPSIR framework is proposed for converting the vulnerability of land use systems to degradation by erosion into information that is readily usable by policy makers since it identifies possible responses, and the *on-site* and *off-site* impacts.

According to EEA, in the case of soil erosion, DPSIR model is enforced in order to set up some relevant indicators to justify and take the decisions regarding the necessity of implementation of soil erosion measures as well as their selection. Such indicators for soil erosion have to have the main characteristics: soil loss and its impact both on- and off-site must to be measurable [1].

The consequences of soil erosion and sediment deposition occur both on- and off-site. On-site effects are particularly important on agricultural land where redistribution of soil within a field, the loss of soil from a field, the breakdown of soil structure and the decline in organic matter and nutrients result in a reduction of cultivable soil depth and a decline in a soil fertility. Off-site problems result from sedimentation downstream, which reduces the capacity of rivers and retention ponds, enhances the risk of flooding and muddy floods and shortens the design life of reservoirs. Sediment is also a pollutant in its own right and, together with some chemicals carried downstream, can increase the level of nutrients in water bodies, contributing in this way to eutrophication. Compared with on-site impacts, off-site impacts are more easily measured and can be expressed in economic terms. In some EU countries, there are subsidies provided by the EU for remedial works via CAP. Such remedial measures usually follow major floods and are linked to flood forecasting systems.

Coming back to the indicators for soil erosion, the main driving force on soil, that causes erosion in several regions with potential and actual soil erosion risks, either all over the world or in Romania, is the intensification of agriculture, especially in our country the land restitution process according to the Law no 18/1991. The corresponding pressures are cost-effective but unsustainable land use practices, the use of machinery for the cultivation of enlarged fields, the overgrazing and other instruments of intensive land use practices. Also, land cover change and precipitation can be used for pressure indicators of soil erosion, as they are seen to be directly influencing the degree of soil erosion. As regard to the state indicator, the most appropriate, from a scientific and technical standpoint, it seems to be the area affected by erosion, under different forms and intensities. Concerning the indicators of responses, an important indicator is the expenditure for national/regional/local agricultural programmes to enforce sustainable farming management systems, that include almost all types of measures mentioned roughly above, but especially the sustainable agri-environmentally practices, being in close connection to the EU CAP reform.

Roughly, the conceptual model DPSIR enforced for soil erosion has the following elements/indicators (see figure 3) and we strongly recommend its utilization in Romania too, for analyzing erosional aspects.

Having in view the great importance of soil conservation all over the world, and especially at the EU level, as soil has been one of thematic strategies under the 6 Environmental Action Programme, the EEB is currently preparing the Soil Framework Directive (SFD). The Directive, something similarly to WFD, will seek to address key threats to Europe's soils, such as erosion, contamination, sealing, organic matter decline, salinisation, compactation, biodiversity loss and floods.

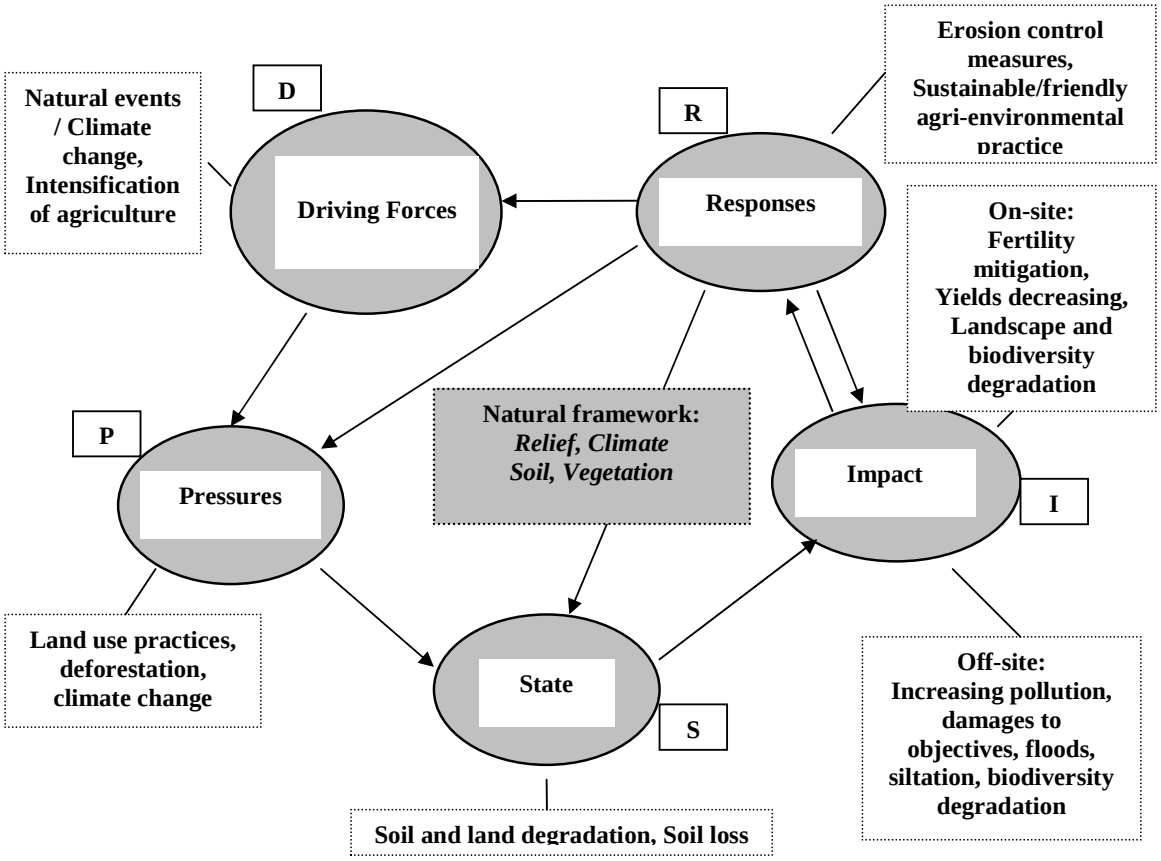

Figure 3 Structure of DPSIR conceptual model for soil erosion
(adapted after Mirco Grimm et al., 2002)

5. ACKNOWLEDGMENTS

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