ECOLOGICAL STATUS OF SOIL COVER AND RISK ISSUES FOR POPULATION: REPUBLIC OF MOLDOVA

Tamara LEAH[1], Corina LEAH[2]

e-mail: tamaraleah09@gmail.com

Abstract

The degradation of agricultural land in Moldova is a serious problem, largely related to agricultural management. The main forms and types of soil degradation are presented by water erosion processes, loss of humus content, long-term use the land on the arable, destrcturation and compaction, salinization and alkalization, etc. Ecological status of soil cover in the last 25 years has led to increased the migration flows, unemployment, development of chronic diseases of the population, worsening environmental situation in the region. Ecological status of agricultural land is influenced to climate change, effects of agricultural reforms, other economic and social factors. Soil protection must be one of the objectives of the National System of Land Monitoring within which it is necessary to develop ecological norms and standards from land use. First of all it is necessary to establish optimal and critical levels for various soil indicators according to their genesis, climatic zones, crops and cultivation technologies, to make long-term prediction on soil quality and to present concrete recommendations for regulation of unfavorable processes. Moreover, a great attention should be given to measures necessary to adapt soil resources, crops, pastures and livestock to climate change - drought conditions.

Key words: ecological status, soil degradation, soil protection, risk issues

Moldova - the country with predominantly agricultural economy and the population welfare depends on the quality status of soil cover, in the structure of which chernozems occupy 70% of the total area of the country and 82% of agricultural land area. Land degradation and loss of biodiversity is the most dangerous ecosystem change affecting the lives of the more poor population sector - agriculture. Land Fund of Moldova is divided into more than 2.5 million privatized plots. The total area of farmland after land reform was reduced to 18 thousand hectares (land degradation), perennial plantations - to 65 th. ha (uprooting orchards and vineyards with new landowners). At the same time the cultivated area increased by 30 th. ha, and pastures - by 9 th. ha (Leah T., 2013). The irrigation system of soil was put out of action for more than 250 th. ha, once irrigated land (Monitoringul, 2010).

Moldova is a country with a low-income population, is therefore very vulnerable to environmental change and soil degradation. In terms of soil degradation has increased the level of unemployment and the flow of migration from rural to urban areas or in other, more prosperous countries. Ageing factor of population (number of persons aged 60 years and over per 100 inhabitants) stood at 14.7 in 2011, 10.4 in 1980. On a scale of God-Jean Garnier, with the value of the index above 12 the process is classified as "population aging" (Anuar Statistic, 2013).

Thus, soil degradation, natural ecosystems modification largely determine the quality of population life. Therefore, they require monitoring and management activities to ensure their protection ant stabilization.

RESULTS AND DISCUSSION

Ecological status of soil cover of Moldova. Land and soil degradation represent *"a decline in the land and soil quality, caused by human misuse"*: inadequate agricultural practices, massive and uncontrolled deforestations, land over-grazing, industrial pressure on environment, burning the stubble, etc (Strategy, 2011).

Inadequate agricultural practices are mainly represented by over cropping of agricultural lands, soil tillage done along the slope, exaggerated rate of weeding crop in crop rotations, soil compaction caused by heavy machinery, irrigation misuse, irrational use of fertilizers, etc. In this way, the constant agricultural activities without taking into account the specifics of the soil and characteristics

[1] Institute of Soil Science, Agrochemistry and Soil Protection "Nicolae Dimo", MD-2070, Chisinau, str. Ialoveni, 100;
[2] Moldova State University, MD-2009, Chisinau, str. A. Mateevici, 60.

of relief, lead to continuous decrease in soil fertility and land degradation.

Arable land. Unfortunately, till nowadays, sowing, land tillage and generally methodology of growing crops on relief with different slopes is very similar to methodology used for horizontal and non eroded lands. For example, the work of land along the slope causes losses of 20-30% from runoff of torrential rains. If there are 30 mm of rain, then 90-150 m^3 of water per hectare are being lost on the slopes. The wheat crop loss constitutes 1.5-2.0 q/ha (Andries S., 2009).

The concentrated character of the runoff also has a negative impact on the crops. Erosion gullies comprises from 5% to 40% of the slope surface. The runoff caused by the abundant rainfall destroys the soil, uncover the root system of plants. The annual loss of fertile soil represents tens of tones per hectare. As a result, annual losses of nitrogen, phosphorous and potassium determined by erosion exceed several times the quantity of incorporated fertilizers. The soil removed from the slopes is deposited at the foot of the slope, in valleys, ponds and rivers (Eroziunea, 2004).

Over cropping the arable lands can determine the land erosion process, if combined with use of improper agricultural technology, use of inadequate crops and in reduced variety, use of obsolete irrigation techniques.

Irrational use of chemical fertilizer have various negative impacts, causing plant toxicity, soil charging which affects the specificity and population structure of existing microbes, influences the dispersion of soil particles, soil compaction, reduces the soil productivity, raises the degradation risk and causes phenomena of soil elements immobilization. Not using the fertilizers (due to lack of financial resources) has led to exhaustion of nutritive elements in agricultural soils (Andries S., et.al., 2013).

Perennial crop plantations. In the process of vineyard foundation about 550 th. ha of soil have been dug 50-60 cm, which led to disruption of natural stratification of genetic horizons and uncovering the underlying horizons poor in humus and rich in carbonates. The dynamics of vineyard plantations area is represented in *figure 1.*

Soil erosion resistance resulting from uncovering and bringing to the surface of loess clays is very low. The soil which covers vineyard plantations located on slopes and are the subject to extremely intensive erosion process in the first years of exploitation. Therefore the preparation works for founding vineyards on slopes should be done along contour lines of the relief.

Another important aspect regarding vineyards is the reduced steering possibility of agricultural machinery, which determines crossing the same trace several times, and as a result causing increased soil compaction and soil runoff on the slope, erosion and reducing in water permeability. Soil structure deterioration and soil secondary compaction characteristic for the whole area of vineyards encompassed by intensive agricultural works.

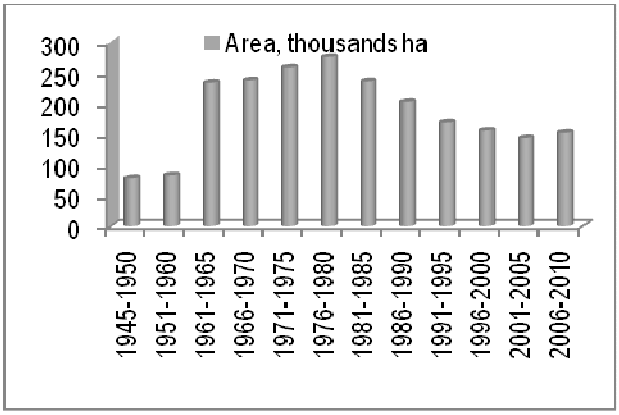

Figure 1 **Dynamics of vineyard plantations area in Moldova**

Often, when creating the erosion management plan of arable lands and vineyards the relief of the land is being ignored. Roads and land parcels are organized along the slopes and as a result trenches and ravens are being formed. Frequently this creates conditions for runoff concentrations in diverse surface irregularities, incorrect leveling of contour line roads, cross plowing along superior dead leaf coverage of forest stripes, irregular furrows that bring together water runoffs from surfaces above and direct them to a second slope at a distance of 300-400 m in a trench, where then a ravine is formed.

The soils that are damaged by deep subsoiling / digging are not taken into account in the inventory lists. This does not allow estimating the loss in soil organic matter, the secondary compaction processes and the deterioration of soil structure. Annual losses of fertile soil, humus and nutrients, harvest (grapes and fruits) for perennial plantations are presented in *figure 2, 3 and 4.*

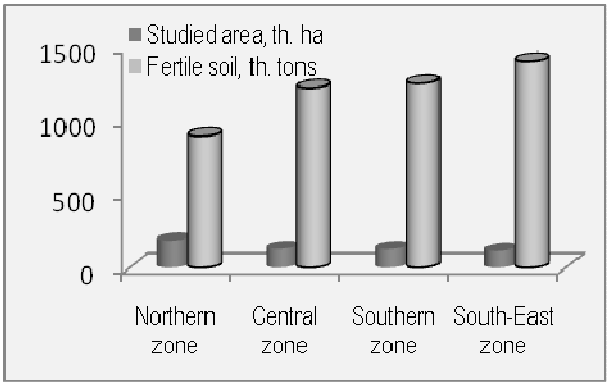

Figure 2 **Annual losses of fertile soil in the perennial plantations caused by erosion**

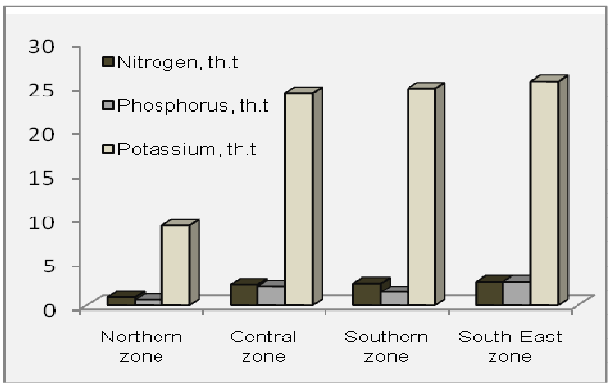

Figure 3 **Annual losses of nutrients in the perennial plantations of Moldova**

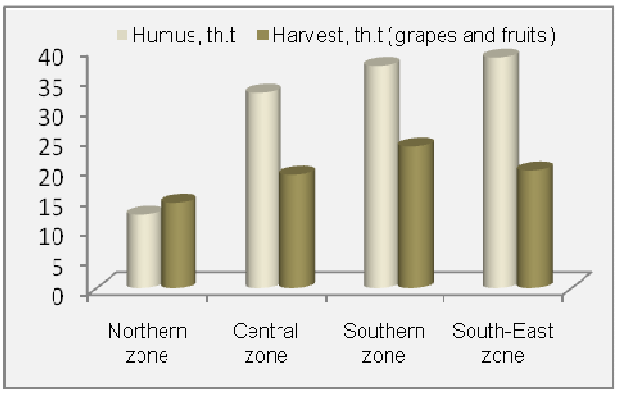

Figure 4 **Annual losses of humus and harvest (grapes and fruits) in perennial plantations**

Fertility of trenched soils used for field crops in average is 10-20% lower than the similar soils that are undisturbed. Field crops cover 176 th. ha of trenched soils. Nowadays 10-15% of areas of vineyard plantations are located in lowlands – valleys, meadows. The medium reduction of soil productive capacity, as a result of trenching as degradation factor constitutes 10-20% (Nirean E., 2013).

In order to appreciate and assess conditions and quality of trenched and antrophic damaged soils of vineyard plantations it is necessary to conduct *special research works* that would establish measures of their rational exploitation, as well as make the needed changes in diminishing their fertility in the frames of Pedological Monitoring, as a result increasing the amount of areas with soils that were transformed or damaged in the process of trenching (*figure 5*).

Meadows, pastures and hayfields are considered vulnerable areas, where there is registered systematical exceeding of standardized norms of environmental quality indexes, which leads to serious damages of environment status. The area covered with meadows is in constant increase, while the area occupied by arable lands and perennial plantations has decreased.

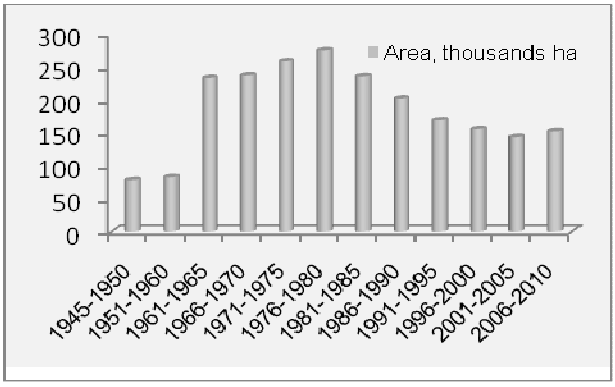

Figure 5 **Area of trenched and transformed soils**

This decrease in arable area is determined mostly by the fact that after 1990 certain areas were not introduced in the category of agricultural lands. Another reason that determined changes in pastures surfaces is the property type. In Moldova pastures are not privatized, they are a public property. Currently the pastures area occupies 348 th. ha (Leah, 2013).

The area of permanent (natural) hayfields has decreased considerably. If in 1960 the hayfields cover 30 th. ha, then in 1966 its covered 10 th. ha, in 1989 – 3.7 th. ha and in 2014 – 2.1 th. ha. The assessment of hayfields areas for the period 1966-2014 shows a considerable decrease, "minus" 7.9 th. ha (Monitoringul, 2010). Because of the low productivity, a part of hayfields were included in the agricultural cycle and a part of them were converted into pastures Currently hayfields are located on steep slopes and river valleys. The vegetation of hayfields is dominated by xerophytes plants that are consumed by animals only in early spring. During summer and autumn these plants dry and yield poor harvest. During dry periods there is an abundant growth of species of plants that are harmful for animals. This type of hayfields is very vulnerable to climate changes, especially to long-lasting droughts. Hayfields located in floodplains have vegetation full with mesophillic and hydrophilic plants with a high forage value. The predominant species of plants are perennial grasses with high resistance to floods, salinization and drought.

Applying measures and principles for combating land erosion are obligatory measures in the economic activity for the 1300 th. ha of arable lands on the slopes, 300 th. ha of vineyards and orchards and 350 th. ha of pastures. Otherwise the proportion of erosion can reach very high values (Monitoringul, 2010).

According to the Code of good agricultural practices (2007), *overgrazing or excessive grazing* determines *"the transformation of vast agricultural lands into unproductive lands, with negative consequences on animal production, biodiversity,*

soil erosion, pollution and general landscape of the region". Therefore overgrazing is considered to be one of the main causes of land degradation and desertification, by exceeding the carrying capacity of vegetation and soil (Codul..., 2007).

Irrigated soils. Irrigation has an essential influence on the composition and properties of the soil. While being irrigated soils usually are often subject to negative changes. The irrigated lands of Moldova consist mostly of chernozems. These soils have special requirements for water quality, irrigation norms and regimes. Using for irrigation low mineral water of Dniester and Prut rivers, which has an alkaline potential, leads to unfavorable chemical changes.

The use of alkaline mineralized water from reservoirs and small rivers for irrigation have unfavorable influence on the soil properties. It was determined that after irrigating the common chernozem for 3-4 years with mineralization water with 2.5-2.8 g/l changes it to the category of low salinizated soils with more than 0.2% residue. After irrigating for 10 years this soil has become moderately salinizated - >0.4% of slightly soluble salts in the superficial horizon (Seceta, 2007).

Irrigation with unfavorable water can lead to degradation of the adsorptive complex. Already after the first irrigation season the amount of adsorbed sodium exceeds 5% of the cationic exchange capacity, and after 10 years of irrigation this indicator exceeds 14% (Seceta, 2007).

Regardless of water quality the halochemical situation on the irrigated landscapes can be substantially aggravated by raise of ground waters. Forecasts in this field show that the most unfavorable situation for improvement is in the northern districts of Moldova, where the impermeable layers is located at the depth of 12 m. According to calculations, in 10-15 years of irrigation the water level reaches the critical level of 30-50% of the irrigated area. Moreover, the raise of water table opens up access to salts from soil and underlying sand rock as a result contributes to mobilization of slightly soluble salt and therefore progressive evolution of secondary soil salinization and alkalization of irrigated soils.

Deforestation of terrestrial ecosystems is one of the triggers of desertification phenomenon. The evolution of human society has always been in an vicious synergy with deforestation and need for more fertile soil. As a result strong ecological consequences raised due to changes in equilibrium in natural water cycle and water regime, thus facilitating the emergence of floods, soil erosion, landslides which lead gradually to landscape and environment degradation.

Spontaneous or intended wildfires is one of the main threats for the vegetation layer. Burning stubble has a negative effect on physical, chemical and biological properties of the soil, as burning the vegetation reduces an important amount of organic matter derived from plants decomposition, it determines the evaporation of nitrogen contained in plants and soil, the soil meso- and microfauna from the superior layer is largely destroyed and water quantity is reduced because of evaporation. All these results determine soil vulnerability towards erosion, degradation and fertility loss.

Industrial activities, besides determining an unprecedented socio-economic development which we have nowadays, have a range of negative impacts on the environment. Soil often serves as *techno-industrial* component and is being polluted with wastes and various secondary products, which reaching to groundwater, streams, rivers expand the area of contamination.

Ecological risks for population and environment are manifested by land use management and non-agricultural activities, poverty, over-population, government policies, one or some of them being indirectly involved in land degradation in any region of the world.

Land use management and non-agricultural activities represent the result of long-term interaction of diverse climatic, historical, social, economic, cultural and religious factors, which changed land destination and planning depending on demographic growth and urbanization. Starting with XIXth century and during almost all XXth century natural forest and meadow ecosystems have undergone significant changes by being transformed in vast arable lands as part of the itinerant agriculture way of managing lands. Parallel to this, the intensification of agriculture reached above the natural level of soil supporting capacity in this way causing a sudden decline of soil fertility (Monitoringul..., 2010). In a period of 200 years the arable land expanded 3.5 times, perennial plantation – 6.5 times, and grassland areas decreased 6 times (*table 1*).

Table 1

Evolution of land use in Moldova (1812 – 2014), %

Year	Arable	Perennial plantations	Meadows	Forests	Other lands
1812	11.4	1.0	48.8	12.1	26.6
1853	33.6	2.1	54.1	7.7	2.5
1900	66.3	3.1	17.1	6.0	6.1
1950	64.4	5.4	16.4	7.0	6.7
1980	53.7	10.4	11.1	11.3	13.4
2008	53.8	9.0	10.6	13.4	13.1
2012	53.5	8.8	10.3	13.7	13.6
2014	53.6	8.7	10.3	13.7	13.4
200 years	+42.1	+7.8	-38.5	+1.6	-13.0

In the last 80 years, as a result of demographic growth, the area of arable land per capita in Moldova has decreased from 0.71 in 1930 to 0.41 in 2013. Regarding the area of arable land Moldova has a value near double to global average, which is 0.26 ha/capita, and double to the European – 0.236 ha/capita (Chivriga V, 2009).

Abandonment of low productive lands is a common practice especially in economic context, and leaving these lands "drained of fertility" as fallow lands without perennial small vegetation layer which can lead to deterioration of soil characteristics through erosion, structure deterioration, compaction, reduction of water permeability etc. The increasing area of fallow lands is already a common practice after privatization, phenomenon caused by several social factors: population ageing, lack of labor forces, lack of financial resources, rising price of fuel, low price of agricultural production, etc.). Since privatization, during 25 years, the areas of fallow lands have increased with 38.7 th. ha or with 1550 ha/year.

Poverty generates the emergence of degradation process as a result of way the community is managing the soil/land resources. It is known that poor people are open to change their life conditions in exchange for some immediate benefits, often with consequences opposed to medium- or long-term sustainable development, resulting in a vicious circle where poverty leads to land degradation processes, which in turn hence socio-economic problems of local population.

According to the *Global Wealth (2010*) report prepared by the Swiss bank "Credit Suisse" - Moldova is the poorest country in Europe. This report refers to 40 European states, Moldova being the last one, with a GDP of 2500 USD.

According to the Eurostat data (*European statistics agency*) Moldova is at the bottom of the continental ranking regarding GDP, income and purchasing power of the population per capita. It is ranked 44^{th} of 44^{th} countries regarding these indicators of living standards, with a GDP of 861€, so Moldova has not achieved any significant economical development and remains the poorest country in Europe (Flux, 2010).

Demographic pressure determined by over population as a factor often cited by researches as responsible for degradation of natural terrestrial ecosystems and therefore degradation of lands. William C. Clark gave a simple definition of the demographic implications in the degradation processes (1986) as being *"an increase in demand on environment to support simultaneously increasingly more people with the destruction of natural resources base"* with perspective on the relations between population density, growth rate dynamics and level of development of communities.

Governmental policies reflected at local, regional, national and international scales authorities' concern for creating a proper environment for implementing sustainable development of surroundings, favoring expansion of sustainable agriculture, protection of degraded or in ongoing degradation areas through programs of their rehabilitation; or the ignorance about complex problems of the geoecosystems that are determined by *lack of synergy between scientific world, development strategies and policymakers*.

Until 1990 the exaggerated intensification of agricultural production and land shafts ecological unbalance were the main causes of manifestation of massive soil degradation processes in Moldova. In the following period, after 1990, such political events as adaptation of the *Land Code law, land reform and land privatization, introduction of market economy regulations and liberalization of foreign trade* without a balanced protection for the local farmers had a marked impact on the land resources and the agricultural system in Moldova.

Intensive agriculture is based on the use of chemical fertilizers, herbicides, fungicides, insecticides, plant growth regulators, etc. It is also associated with increased mechanization of agriculture. Intensive agriculture is responsible for serious environmental, social and human health problems. Recent years have shown that these effects have been manifested in several ways: depletion of soil fertility over time (some of the most fertile soils were turned into degraded lands due these practices), spread of pathogenic organisms (through animal waste), transport of pesticides and nutrients to the ground waters determining by soil erosion. These factors and critical destruction of habitats contribute to a substantial degradation of biodiversity.

Nowadays we are using more pesticides than 50 years ago and the chemicals that are being used are 10 times more toxic. At the same time we lose annually more products than those lost before using these types of pesticides. Intensive agriculture is largely responsible for the surface water pollution and the pesticide residues in groundwater. Agriculture is responsible for 50% of the nitrogen pollution of rivers. With the help of rainwater, chemical synthetic fertilizers drain and reach ground waters. As a result there is chemicals accumulation in water sources, destruction of natural ecosystems and water pollution. Thousands tons of fertile soil are lost annually because of intensive agriculture practices. As a clear evidence of the arable land environmental degradation can

be used the fact that during the last 25 years the birds associated with this kind of ecosystem have been reduced to almost half in number.

*Ecological unbalance***.** Currently, natural ecosystems areas represent 18% and those anthropic modified – 82% of the territory of Moldova. It is known that loss of 20% of total amount of species causes deterioration of ecological balance and preservation of 10% of natural ecosystems are capable of preserving 50% of the total amount of species.

In Moldova the optimal ecological ratio of natural and anthropic modifies ecosystems is not strictly determined. The ecological unbalance between natural and anthropic ecosystems is a *relative notion* and therefore it is assessed quite approximately as the correlation between natural ecosystems and agro ecosystems present in the country, which in Moldova is 1:3 or 917.5 th. ha: 2533.8 th. ha (Leah, 2011).

Land reform has radically changed the structure and use of land property. It has ensured land solvency, has increased number of participants in land relations, and has generated a diversity of soil management and land property types. However, these and other modifications of land management did not succeed in creating proper conditions for soil protection, improvement, sustainable use, enhancing its fertility and increase the agricultural production. *Land parceling has favored the development of soil degradation.*

Studies in agricultural economy have shown that the structural changes that occurred in agriculture after 1989 by application of Land Law have determined important changes in the crop structure in the country. As a result, small family farms became predominant in terms of private land property and they are based mainly of self-consumption rather than products marketing. Due to the fact that cereals are grown on small areas, with minimum expenses on foundation and maintenance, the yielded crops are poor and influenced by climatic conditions, especially by droughts. Consequently, farmers' income is in accordance with low productivity, and droughts that occurs year after year makes many farmers unable to resume the agricultural cycle.

The quality of soil has worsened during the last 25 years period of intensive exploitation. In these years there has increased the areas of eroded soil, lands affected by landslides, anthropic damaged and destroyed by natural hazards, salinization and alkalization, degraded as result of improper irrigation, silted with deposits poor in humus etc. The process of soil structure deterioration and compaction has intensified under influence of soil tillage. Given the deficiency of mineral and organic fertilizers the humus and nutrients balance has become negative. All these factors led to continues reduction of soil fertility and degradation of pedodiversity and environment.

CONCLUSIONS

Environmental degradation and loss of ecosystem stability will directly affect pests, soil erosion and nutrient depletion, growing conditions through climate and weather, as well as available water for irrigation through impacts on rainfall and ground and surface water. These are factors that individually could account for over 50% in loss of the yield in a drought year and affect ecological status of environment and quality of life.

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