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# LAND RESOURCES MANAGEMENT AND SOIL DEGRADATION FACTORS IN THE REPUBLIC OF MOLDOVA

LEAH TAMARA<sup>1</sup>

## Abstract

*Land resource management includes three interrelated levels: national, district and commune. The purpose and basic objectives are: state land policy implementation, legislation and regulations in force, effective implementation of measures to protect soil cover, to maintain ecological balance and biological diversity in ecosystems of the Republic of Moldova. The soil cover quality on the most agricultural land is unfavorable, and on some land - critical. Continue to expand the area affected by erosion and landslides, dehumification processes, damage of structure and compaction, sodium enrichment, salinization and soil swampy, drought intensified. Land management in the Republic of Moldova should be a process of development and implementation system of organizational, economic and administrative levers. They would allow regulation and development the forecast of quality land status; develop recommendations on the rational use of land, combating soil degradation processes and long-term preservation of agricultural production capacity. Basic information for proper management of land resources must become computerized information system of the state of soil quality.*

**Key words:** agriculture, land recourses, soil cover, soil degradation, soil evaluation

## INTRODUCTION

Soil is a natural body with a organo-mineral complex composition and properties that provides the necessary conditions of plant growth. Thus said, soil holds fertility - the ability to produce agricultural production. As support and living environment for humans, plants and soil animals is an inestimable wealth of all people, irrespective of ownership, must be used according to the interests of national economic development, in accordance with applicable law. Proper management of soil fertility resources is a primary social problem for Republic of Moldova.

Soil resources and use them in agriculture have their ecological and economical aspects. Republic of Moldova is characterized by very complexicity of soil cover. The soil variability and zonality of the territory are caused by climate change, topography and vegetation, from North to South of Moldova. Depending on climate and soil zonality in Moldova are highlighted three agropedoclimatic areas: North, Centre and South, which is divided into subareas [3, 4].

Main soils in Moldova are chernozems, area of 2 million 510 thousand hectares or 70% of the land. Under the forest steppe and steppe vegetation formed several subtypes of chernozems area: luvic or podzolic (3.5%), cambic or leachates (11.7%), typical (8.3%), ordinary (18.8% ), carbonate (19.9%), southern (0.1%) of land surface and intrazonale subtypes (7.3%).

Under recent and previous forest vegetation (altitude 200-300 m) have evolved the zonal soils: grey (9.8%), brown (0.8%); xero-forestry chernozem (0.5%) of land area.

Brown and Gry soils, cambic chernozems of Central Moldova were formed as a result of vertical zonality and differ from similar soils in Northern Moldova with a more favorable temperature regime (sum  $t^{\circ}>10^{\circ}=3000-3150^{\circ}$ ). Areas of these soils are extremely favorable ecological niches for placing precious vineyards with varieties of fine quality wine production. An important group of soils, as its use in agriculture (can be easily irrigated) and the ecological niche for the conservation of biodiversity, are hydromorphic soils (300 thousand ha or 8.4% of the total land).

Basic characteristic of the soil, which largely depends on favorability and their suitability for crops, is texture. In Moldova the most widespread are clayey-loamy and loamy textured soils (62.1%). These soils are characterized by high productivity if the content of humus in the arable layer is greater than 3.0%. Less favorable soils are loamy-clay (8.5%). Fine clay soils (41thousand

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ha or 1.2%) are unfavorable for use in agriculture, their use is recommended for grasslands and forests [2, 3].

## RESULTS AND DISCUSSIONS

The land fund of the Republic of Moldova at 01.01.2012 is 3384.6 thousand ha, agricultural land occupies 2498.3 thousand ha (73.8%), including arable land – 1.812.7 thousand ha (53.6%), perennial plantations – 299 thousand ha (12%), meadows and pastures – 353 thousand ha (14%), fallow land - 34 thousand ha (1.4%). Is only 0.5 hectares per capita of arable land and perennial plantings, including 0.4 hectares of arable soils. Exceedingly high rate of agricultural land in the composition range leads to the manifestation of processes of soil degradation and land desertification [5].

Land reform in Moldova, as a result of inadequate strategy has not created conditions for increasing the soil fertility, sustainable land use, increasing agricultural production, exerting therefore a negative impact on national economy. Privately owned land area – 1882 thousand ha (55.6%), number of land owners increased from 1845 owners in 1990-1991 to 2366 thousand owners today. During the 20 years of reform have been deforestation and irreversibly lost more than 150 thousand ha of perennial plantations [5]. The main problem imposed by consequences of land reform is need for further consolidation of agricultural land. Land reform has resulted in massive acceleration of soil degradation processes and substantially reduces their fertility. In condition of subsistence agriculture, created as a result of land reform, Moldova risks losing the greatest wealth of the country – chernozem's fertility. Rational distribution of land in the national economy and sustainable use of soil resources should be based on two basic principles:

- Produce the necessary volume of agricultural production to meet population needs and export;
- Organization of agriculture in a way that the agricultural production to protect soil and enhances fertility.

### *Soil degradation and the factors responsible for degradation*

The quality of the soil cover of Moldova on most agricultural land is unsatisfactory, and on some land - critical. Continue to expand the area affected by erosion and landslides, dehumification processes, damage to structure and compaction, compactation, sodium enrichment, salinization and swampy, acute drought are intensified. These processes lead to disruption of biological cycles, balance of nutrients and humus in the soil, deterioration of soil and decrease their fertility. It creates the situation in which any social problem can be solved only by maintaining the ecological balance, environment and soil protection.

In the early of '70 the weighted average rating note of agricultural land was equal to 70 points. According to the Land Cadastre (2012) the average rating note of agricultural land now is equal to 63 points; fell in this period by 7 points [5]. The price of 1 point/ha per year is equal about 47 lei. Annual losses as a result of decreasing soil reliability note, measured by loss of agricultural production is 330 MDL per ha and 83 million MDL for the whole area of agricultural land (tab.1). The main factors of soil degradation are presented in tab.2.

According to soil surveys, soil eroded area increased over 40 years with 284 thousand ha (594 thousand ha in 1965 and now 878 thousand ha), increasing annually by 7.1 thousand hectares. Eroded soil fertility decreases in the following: weakly eroded - 20%, moderately eroded - 20-40% highly eroded - 40-60; very highly eroded - 60-80%. Along with surface water erosion, is widespread the deep-water erosion. Gullies on agricultural land area increased from 8.8 thousand ha in 1999 to 11.9 thousand ha in 2012. Rational management in agriculture in recent years generates decrease of number and ravens surface.

Damage caused by erosion to national economy is tremendous. The annual loss of fertile soil is 26 million tons which is equivalent to the destruction of 2000 hectares of black earth with the whole profile evaluation to 100 notes. The amount of fertile soil contains: humus - 700 thousand tons, nitrogen – 50 thousand tons, phosphorus - 34 thousand tons, potassium - 597 thousand tons.

The cost of washing soil to the cost of legal land (1 ha – 926.496 lei), is about 1.850 million lei. Agricultural production is not obtained due to soil erosion, consists 525 thousand tons of nutrient units on the arable land and 57 thousand tons of fruit and grape on the perennial plantations lands. Given the price of 1.5 lei per nutritive unit and 1 kg of fruit and grape harvest, cost is lost yields due to erosion is 873 million lei. Indirectly, the damage caused by erosion extends to other spheres of human activity: bogging up of ponds and other water bodies, pollution of depressions soil, surface and groundwater with pesticides and chemical fertilizers washed from the slopes, destruction of communication, hydro and social construction, etc. [1-4].

**Table 1. Quality statuses (soil rating) of the soil cover of agricultural land**

Soil rating clas	Soil rating, points	% from agricultural land surface	Surface, thousand ha	Winter wheat crop, q/ha
I	81-100	27	680	32-40
II	61-80	36	907	24-32
IV	41-60	24	604	16-24
VI	21-40	6	153	8-16
VII	<20	7	178	0-8
Average	63	100	2518	25

**Table 2. Soil degradation factors of agricultural land**

Soil degradation factors	Surface, ha
Water erosion	839,7
Landslides	81,0
Damage to soil as a result of landslides	24,6
Ravines damage soils	8,8
Soil damage by excavating	5,0
Overburden soils on artificial terraces, recently abandoned	5,0
Unclogging soils	546,4
Reducing production capacity of unclogging soils as a result of their use in field crops	175,7
Clogging soils with low humifere deposits	119,0
Secondary compaction of soils as a result of their intensive use	2183,0
Primary compaction (slitization) of vertic soils	60,0
Excessive soil moisture on the slopes and valleys	49,6
Excessive humidity of alluvial soils	259,0
Salinisation and alkalization of soil on the slopes and valleys	20,0
Salinisation and alkalization of aluvil soils	99,0
Solonezization of authomorth soils	25,0
Dehumification, small (<3.0%) and very low (<2.0%) reserves of humus	1037,0
Ensuring unsufficient land with mobile forms of phosphorus	785,0
Soil degradation as a result of irrigation	12,8
Drought and other natural disasters	256,0
Land allocation for social needs	120,0
Total damage of soil cover on land allocated for social needs	40,9

A great economic and ecological damage on the land and the national economy in general is caused by landslides. Land area damaged by landslides is 24.6 thousand hectares and increase annually by about 100-300 ha.

Dehumification, structure deterioration and secondary compaction of soils are interdependent factors of soil degradation. Research has found that arable chernozems, compared with fallow, have lost about 2.5 to 3.0% of humus from 0-30 cm layer. Deterioration of structure and dehumification of arable layer as a result of the existing agricultural activity led to compaction of arable layer of chernozems and grey soil with negative consequences for the physical condition of soils.

Periodic excess of soil moisture and appearance swampy processes, salinity and sodium enrichment is widespread in the Prut, Dniester, small rivers valley and on the slopes.

In recent years, with the increase of cattle numbers and excessive grazing in countryside, the the ecological situation of pastures suddenly has worsened. As a result of worsening occurred initially, and then total degradation of these lands. Because of the high concentration of livestock in rural area the environmental situation of health of rural space has worsened.

Reducing the amount of organic and mineral fertilizers by 20-30 times and failure of agricultural technologies and crop rotations have led to an uneven balance of humus and nutrients in soils and decrease crop yields by 20-30% [1,3].

#### ***Necessary measures to improve farmers' agricultural practices***

Rational land management means the combining technologies and activities in such way as are done concomitantly: bioproductivity, food security, protection of soil quality, economic viability and social acceptability. This can be done if it acts primarily on the main objective - protection of soil quality. Maintaining long-term productive capacity of the soil, increasing its fertility, is the primary strategic goals of farmers. The attitude toward on the soils is depends the country's economic situation. Therefore, every citizen, first, every farmer, land owner and economic agent, should be informed about the status of soil quality and to participate actively in the implementation of necessary measures to protect and enhance fertility. With the intensification of agriculture is creating new opportunities and positive anthropogenic influence on soil productivity. These possibilities can be achieved through improving the system of territorial organization of the land based on the ecological princes of maximum evidence of all natural landscape features.

Most measures to combat degradation processes of the soil cover are aimed at eliminating these processes, but not the causes that generate them. It is now evidence that such an approach to the problem will not result in its settlement. Removing of this shortcoming is possible by transferring socio-economic problems in the center of analytical and practical activity and addressing these questions with the same attention is given physical, chemical and biological forms of soil cover degradation.

#### ***General measures:***

- Improving national pedological and agrochemical soil research, creating a computerized information system for soil quality (soil quality monitoring status) for the management and proper use of the land at plot, agricultural, common, district and country level;
- Development of standards, technical reglamentation, general aspects, norms of agricultural land;
- Improve land law, solving problems of calculating land tax, land price, the rent, tax on land transactions, collected and use the funds in the form of land payments;
- Specifying form and limits the performance of state supervision of land transactions, contractual relations and policy responsibility for these relationships;
- Consolidation of land holdings in profitable optimal size, which would allow implementation of crop rotation and technologies, develop a system of sustainable use of soil resources;
- Creating a economic mechanism that would ensure sustainable improvement of price and tax credit policy, which would provide special-purpose programs in agro-industrial complex, especially in the protection, improvement and rational use of the land;
- Creating in different climatic areas the model of specialized farming households, high-yield and optimal sizes, determining the optimal size of farms of different specialties, taking into account soil conditions and economic specific of territories;

#### ***Measures concerning rational distribution of soil resources***

Distribution of agricultural crops in the arable land should ensure a harmonious co-report of the field crops and livestock, which would provide annual production of at least 10 million tons of manure, needed to stabilize humus balance the soil and thier fertility preservation. It is recommended following use of 1.8 million hectares of arable land: perennial grasses (lucerne and



esparceta involving up to 30% of grasses) - 20-30% (it will restore the soil structure, production the protein for quality fodder and 35-40 tons of biological nitrogen); grain - 25% corn - 20%, sugar beet - 7%, sunflower - 8%, tobacco - 3%; vegetable cultures - 5%, potatoes - 3%; hetero-oleaginous cultures - 1%, forage crops - 8%. The recommended structure will allow crop production volume required: grain for food security of people, feed for livestock, technical and vegetable crops for processing needs of industry and population. Along this crop structure will allow apply in the agriculture soil protective crop rotations.

***Measures related to combating soil compaction:***

For compaction control of the arable layer of soil is recommended:

- application of organic fertilizers from all possible sources - storage and incorporation of plant residues, manure, compost, green manure, crop intermediate complexes sludge from livestock and household waste (last two only after special training);
- introduction to soils with acid reaction of arable layer, along with organic fertilizers, 4-6 t/ha of defecate from sugar factories to create in the arable layer a reserve of  $\text{CaCO}_3$  that will contribute to the formation of hidrostabile aggregates and improvement the structural status of the soils;
- perform at least once in three years the autumn plowing at 35 cm of depth, to which was plowing in the years until the land reform in aimed to destroyed underlying arable layer recent compacted;
- application of crop rotations with a 20-30% of perennial containing it takes up to 30% of grasses.

Along with the traditional tillage is necessary to implement progressively "mini till" system for soil conservation. Application of this system is subject to the production of machines suitable for executing several combined operations, the use of insecticides, fungicides, herbicides, fertilizers and machinery for their incorporation into the soil, knowledge of the peculiarities of crops, soil and local climate conditions, the use of crop hybrids varieties and adapted to the conditions created by this technology. To implement this system is recommended:

- Testing the system in 2-3 households and adapted to conditions of Moldova;
- Production enterprises of machines and aggregates necessary for republic.

Unchanging system of chernozems farming will lead to intensification of dehumification processes, destructuration, compaction of arable layer with serious consequences for the status of soil quality and agricultural production.

***Protection measures related to soil erosion:***

- allocation of agricultural uses on the slopes depending of land suitability for arable crops or orchards and vineyards, meadows and forest plantations (conform climatic and relief conditions);
- determining the number of work sole and lots, their shape and size for each slope separately, in accordance with the inclination, slope form and size, sole orientation on the long side overall contours, thus creating the possibility of performing agrotechnical work in this direction and favorable conditions for application the good agricultural practices;
- establishing a optimal network of technological roads, correct size and their location on the slopes (mining roads, located on the general line of the contour, roads connecting the hill-valley with oblique way, slope roads - 2-3°, secondary roads, turning areas);
- establishing a optimal network of channels for removal of excess water directed from the slopes and prevent erosion in depth;
- perform work fighting formations and rain depth erosion: leveling-modeling, channel level, falls and steps, thresholds, dams, consolidation, etc. grassed outlets;
- develop fitoameliorative arrangements: establishment farmland protection forest belts, mandatory establishment of forest plantations on slopes above 30°, afforestation of ravines and landslides, creating woodland protection of aquatic resources, transformation of arable

strong degraded and excessively eroded land into meadows and pastures, grassing outlets, embankments, drains, gullies;

- agro-technical measures to protect soil: antierosion crop rotation, antierosion agricultural technique, cultivation of crops in alternative strips on the 2-5° inclination slopes and alternative strips grassed on slopes with 5-8°.
- erosion control by stabilizing bottom in deep of ravines and banks; grassing and afforestation of ravines banks, work to retention and controlled discharge of water in the catchment area.

#### ***Combating landslides***

The main measures of prevention and control of landslides are the rapid construction of chimney swift rainwater, land drainage in various ways, captures the coastal springs, building fences, retaining walls for banquets, performing works by sealing cracks and leveling-modeling afforestation affected or likely to be affected. Recovery landslides is expensive, but more expensive is neglect, abandonment affected areas. The simplest and most efficient use of the land slipped afforestation with species of tree that rapidly increasing (willow, poplar, locust), which will increase over time to stabilize the landslide. In the republic of Moldova about 22.3 thousand ha of active landslide with deteriorated soil cover requires afforestation.

#### ***Improving degraded by salinization and swampy soils***

Improving the salinization soils has been based on projects developed in natural areas and watersheds. Land improvement works and agropedameliorative measures are:

- reconstruction and maintenance of drainage network usually an area of 88 thousand ha;
- gypsum arranging and salt washing of saline irrigated alluvial soils of the Nistru and Prut meadow area about 50 thousand ha;
- repeated gypsum amendment of 25 thousand ha of arable salinization chernozems;
- introduction of plants tolerant to salinity and sodium enrichment to restore grasslands and meadows, grazing regulation in those territories (area 50-60 thousand ha).

#### ***Soil fertilization with mineral and local fertilizers***

To conserve and improve soil fertility up to 2020 is necessary to take the following actions:

- optimization of crop rotation and biological soil nitrogen accumulation by increasing rate of leguminous in crop rotation as 20-30%;
  - incorporating into the soil of 5-6 t/ha manure, total 9-10 mln t;
  - the annual application of 150-160 thousand tons of chemical fertilizers in active substance or 180 thousand t of amofos and 240 thousand t of ammonia silitra.
  - VAT exemption for farmers to purchase fertilizers and plant protection chemicals.
  - limiting the profitability of importing agrochemical companies at 10%.
- Enforcement action will provide increasing harvests by 35-45%.

#### ***Ecological reconstruction of grassland vegetation***

Measures to improve recovery and extensive grasslands are:

- the regulation grazing based on the capacity of pastures;
- carrying out surface work (harrow pastures in late autumn or early spring, fertilizer, gypsum amendment of alkali land etc.)
- to use mixed hay – pasture or pasture – hay;
- combating soil erosion through afforestation, overseeding degraded land;
- combating salinisation using facilities of improvement works, sowing the plants resistant to salinity;
- restoration of degraded grasslands by creating radical land sown pastures.

#### ***Implementation of sustainable agriculture***

The existing system of agriculture in the Republic of Moldova is extensive, chaotic and lead to lower agricultural output and the degradation of soil and other natural resources. Out of this

situation is the gradual implementation (along with land consolidation) of sustainable agricultural system, in that agriculture and research are concerned not only high yields but also to optimize the system as a whole to maintain soils long-term productivity. Activity in a household with sustainable agriculture is based primarily on the use of natural processes, on biological resources and regenerable sources of household and only the second – on the purchased resources. For each climatic zone of the Republic of Moldova is necessary to achieve sustainable agricultural systems, specific local conditions. To implement sustainable agricultural system is recommended:

- creation of agricultural farms-model with large area (2000-3000 ha) and medium (400-800 ha) in three climatic zones of the country (North, Central and South);
- testing technologies for sustainable agricultural system in these households and their gradual implementation throughout the area;
- creating the necessary infrastructure to provide technical and material support for sustainable agricultural system (machinery, seeds, fertilizers, fuels, pesticides, etc.)
- improving the national research and design system of tillage for the organizing and planning, land reclamation in accordance with the needs and requirements of sustainable agricultural system.
- creating the infrastructure for training, education, extension and advocacy in sustainable agriculture;
- creating a viable economic mechanism that would ensure improvement of price and tax credit policy, which would allow farmers implement sustainable agricultural and technologies system.
- implementation of sustainable farming system for all forms of ownership and management.

The agriculture strategy based on sustainable agriculture and combating degradation of soil cover must be made the term "ecological limits of the territory", which characterizes the natural regeneration limits [4].

## CONCLUSIONS

The quality of the soil cover of Moldova on most agricultural land is unfavorable. Continue to expand the area affected by erosion and landslides, processes dehumification, damage to structure and compaction, sodium enrichment, salinization and swampy soil, drought intensified. Annual loss due to the national economy as a result of soil degradation is 436 million USD. Rational management of soil resources should be based on a combination of technologies and activities aimed at achieving concurrent issues: bioproductivity, food security, protection of soil quality, economic viability and social acceptability. This can be done if it acts primarily on the main objective - protection of soil quality. Most measures to combat degradation processes of the soil cover are directed at eliminating degradation processes and causes that generate them. Integrated agricultural management must be represent the comprehensive initiatives of farm management, which aim, in addition to enforcement, strengthening the positive impact of agricultural practices on the environment and harm reduction, no doubt the economic profitability of farms.

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