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Land degradation and soil contamination

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INVENTORY OF DEGRADATION PROCESSES IN BULGARIA`S AGRICULTURAL SOILS

Soils are among nature's most important resources and the basis for humans, animals and plants existence. It acts as a filter, buffer and transformer between the atmosphere, surface water and the vegetation cover, preserving the environment and humans. It has an especially important role as the source of farming and forestry raw materials.

The development of sustainable farming systems that satisfy the current and the future needs of humanity by long-term preservation of soil functions require knowledge of the limitation and the potential for the use of soil resources.

Soil degradation is a damage and/or deterioration of the soil which has adverse effect on one or more of its functions. The causes could be natural and/or human induced.

The combination between specific natural and agricultural conditions in Bulgaria creates the prerequisites for high risk of occurrence of soil degradation in agricultural lands due to water and wind erosion, compaction, pollution, organic matter decline, loss of biodiversity, salinization and acidification.

The submitted data provide information about the status, the development and the forecasts about the distribution of agricultural land degradation in Bulgaria, highlighting the main threats identified as priority - soil erosion, pollution, organic matter decline, loss of biodiversity, salinization, acidification, compaction.

Types of degradation processes

Soil erosion

Soil erosion is a phenomenon related to the separation and transferring of soil particles by the wind, precipitation of irrigation water during natural and/or anthropogenic processes. Soil loss also has a significant influence on the ecological and economic functions of soil both in the eroded area and in its adjacent areas. Erosion causes reduced depth of the root layer, reduced quantity of nutrients and humidity in the soil; exhaustion of the filtering and buffering capacity of soil decrease of the organic matter in the soils; loss of biodiversity; degradation of the soil structure and soil crust formation; distribution and accumulation of pollutants in water flows and in the sediment accumulation zones. The natural and economic conditions in Bulgaria create conditions that favour a wider distribution of water, wind and irrigation erosion.

<u>Water erosion.</u>

Models forecasting the factors and intensity of area water erosion that have been validated and adapted to the conditions in Bulgaria were used as the basis for a mathematical model for evaluation of the risk of area water erosion according to which the potential for area water erosion of soil exceeds 100 t/ha/y for 10.4% of the country's territory ,19.5% of the soils are at risk at a rate of 40 to 100 t/ha/y, 31.7% – between 10 and 40 t/ha/y, and only 25.9% of the soils are at risk for less than 20 t/ha/y.

Wind erosion.

Wind erosion of soil is manifest on plains and deforested areas. The areas with higher risk of wind erosion are those with low degree of forest cover and soils that are highly prone to deflation. According to the mathematical model developed for assessment of the risk of deflation, cropland with an area of 1,348,750 ha are at risk of deflation of more than 0,5 t/ha/y. The risk is moderate for 19.7% of the cropland areas, moderate to high for 1.4%, high for 11.7% and very high for 2.7%

Irrigation erosion.

The risk of irrigation erosion is negligibly small as far as it affects irrigated lands with inclination of more than 3°, most of which have been abandoned since 1990. The irrigated areas in Bulgaria until 1990 had been approximately 25% of the arable lands. In-depth studies have shown that the risk of irrigation erosion is highest in the case of gravity irrigation along furrows varying between 2.5 and 8.6 t/ha per one application of water and that the application of sprinkler irrigation might reduce soil losses to a significant degree. Most irrigation systems however have been abandoned during the 1990s.

The natural conditions, the management of lands and the inefficient enforcement of the law suggest a high degree of risk for water and wind erosion of agricultural soils. These processes depend on the annual erosive capacity of precipitation and wind, and by the management of lands.

If the current management of farmlands is retained and in light of the increasing trend for the annual erosive capacity of precipitation and wind, the processes of farmland erosion can be expected to accelerate.

There is a need to develop and implement specialized programs for protection of farmlands from erosion that include soil protection and corrective measures consistent with the specifics of the soil, climate and topography.

Soil contamination

Soil contamination is a process of accumulation of harmful natural and/or anthropogenic substances whose behavior and concentrations cause damage to soil functions regardless of whether they exceed the current limit values. Soil contamination causes deterioration of soil functions and pollution of surface and ground waters. The presence of pollutants in concentrations higher than certain levels may have negative consequences along the entire foodchain, in all types of ecosystems, and in other natural resources. The presence of pollutants in concentrations higher than certain levels may have negative consequences along the entire foodchain, in all types of ecosystems, and in other natural resources. The pollution may originate from local (point) sources or from diffuse sources. Usually local pollution is associated with operating mines and industries while farming practices have the highest contribution to the main non-point sources.

Diffuse pollution of soils has been very unpronounced during the recent years due to post-1990 the economic and agricultural restructuring, the heavily decreased use of plant protection chemicals and mineral fertilizers, the ban on use of leaded petrol and increased environmental monitoring of the operating industries.

Past pollution of agricultural lands with heavy metals and metalloids affects an area of 436,600 ha, 61.3% of which are close to industrial facilities. Approximately 1/3 of the agricultural lands polluted with heavy metals and metalloids require special monitoring.

No statistically significant areas of farmland have been registered as polluted with heavy metals and metalloids after 1994/1996.

The nitrogen and phosphorous content data derived from statistical processing of the results for 2004 show that the availability of nitrogen is average (an average value from 408 monitoring points at 1,87 g/kg and a median of 1,60 g/kg) and that the availability of phosphorous is low (average of 0,08 g/kg and a median of 0,07 g/kg).

The economic and farming changes and the increased environmental control on operational industrial processes have lead to a substantial reduction of heavy metals and arsenic in the soils used for agriculture.

The agricultural activities have not caused new loading of the soils due to the decreased use of fertilizers and plant protection chemicals, and also to the programs for environmentally sound agriculture and organic farming, which should be expanded.

Organic matter decline

The organic matter in soils, assessed via the content of humus and organic carbon in the soils, is a complex system of humus substances, proteins, amino-acids, hydrocarbons, fat acids, waxes, resins, lignin etc. The reserve of organic carbon in soils in Bulgaria has been evaluated on the basis of data from measurements of the content of organic carbon and the volume density across layers deep 0-25 and 0-50 cm, and across the entire soil depth. The total content of organic carbon for Bulgaria was calculated at approximately 1.3 Gt.

The highest relative contribution of the total reserve of organic carbon in Bulgaria (27.6%) is from the Cambisoils occupying approximately 18.4% of the country. The Chernozems, Faeozems, Luvisols and Vertisols, whose respective areas are 7.6, 13.0, 20.2 and 5.8% of the country's area contribute respectively 9.4, 14.2, 18.4 and 7.2% in the formation of the total organic carbon reserves. The Gleysol+Hystosol group occupies only 0.6% of the territory but its contribution in the total organic carbon reserve is 1.6.%.

Despite the absence of systematic observations, there are data indicating a permanent tendency towards soil organic matter decline in the cultivated lands. Development and application of specialized programs is necessary to maintain and increase soil fertility focusing on good agricultural practices for maintaining the soil organic matter, integrated with the measures *for soil erosion and soil compaction control etc.*

Loss of biodiversity

The loss of biodiversity is related to: (a) the other soil degradation processes; (b) landscape modifications resulting in loss of the natural habitat of a number of biological species; (c) stubble burning which destroys the entomofauna and flora and disturbs the soil microbial balance thus causing significant reduction in soil fertility.

There are no systematic observations on the loss of biodiversity in farmlands. Limiting the intensity of soil and land degradation processes, the landscape changes, leading to loss of natural habitats and the burning of stubble can reduce the loss of biodiversity.

Crop residues can be used in farming by plowing up, composting, mulching ets., and as annual bedding, crop beds, fodder, briquettes, direct incineration in special ovens, and as raw materials for various industrial productions.

Soil salinization and alkalization

Soil salinization is a process of increasing content of water-soluble salts and alkalization – increasing of exchangeable sodium and/or magnesium in soils in quantities that degrade the properties and, therefore, the productivity of the soils. Approximately 35,500 ha of arable land has been registered in Bulgaria as affected by salinization processes, with 252 ha being salt affected with normal soda and chlorides.

A big part of the salt affected soils in Bulgaria is spread in assossiation with soils of high fertility. The extention of the salinity is potentially possible, because salinisation is closely linked to water movement through the soil profile and the degree of salinisation depends on thr climatic, hydrologic and economic conditions.

Successful solving of salinity problems requires enormous finance support as it can be achieved after eliminating the anthropogenic factors only on the base of complex amelioration activities including soil drainage, chemical soil melioration, soil deep loosening, soil leaching, appropriate cultivation practices."Gentle" management practices combining soil water management, planting salt tolerant and deep rooted forage crops, soil surface gypsuming and appropriate cultivation practices are more sustainable in case of moderate to low salinization.

Acidification

Soil acidification is a natural process which intensity depends on genetic origin and also on human factors and is characterized by reduced soil pH, occurrence of exchangeable acidity and development of aluminium and/or manganese phytotoxicity, reduction of bases in the soils, molybdenum deficiency, suppressed microbiological activity and acidic destruction of clay materials. About 1 500 000 ha of the cultivated land approximately 11% of cultivated areas, are with acid reaction. About 500 000 ha of the acidified agricultural lands are with a toxic for the plants soil acidity and needs of melioration activities.

Acidification of Bulgarian soils under the influence of acid rainfalls has a limited significance. Acidification of soils caused by acid industrial wastes is limited to confined territories close to point source pollution.

One of the major reasons for along-term mineral fertilization with acidifying nitrogen fertilizers, particularly when applied individually without concomitant phosphorous and potassium fertilization. Acidification of Bulgarian soils under the influence of acid rainfalls has a limited significance. Acidification of soils caused by acid industrial refuse is limited to confined territories close to point source pollution.

Permanent tendency has been established to neutralization of the exchangeable acidity in the anhtropogenically acidified soils due to reduced application of hydrolotically acid mineral fertilizers.

Soil compaction

Soil compaction is a process of deformation and increase of soil bulk density and compactness accompanied with decrease of the soil aeration porosity and water permeability, increase of soil penetration resistance, deterioration of the soil structure and modification in soil profile. The process of soil compaction is connected with cultivation and unsuitable tillage operations, grazing and intemsive livestock moving.

Soil compaction is associated with respective decreases of the soil aggregate stability ranging from 40 to 80 % and the available soil moisture from 1 to 29 %. Aggregate stability of most than 60 % of Bulgarian soils at virgin conditions can be categorized as good and only of 3 % of them – as weak. The anthropogenic load causes deterioration of the soil aggregate stability, which is dominating weak for the cultivated soils.

Despite the absence of system permanent tendency to a structural degradation of Bulgarian agricultural soils.

Development and application of specialized programmes is necessary to maintain and improve soil structural stability focusing on use of agricultural machines with a reduced ground pressure, good agricultural practices for maitaning and restoration of soil structure, integrated with the measures for controlling soil erosion and decline of soil organic matter, as well as application of machines and devices for soil processingwith reduced pressure.

Status, development and forecasting of the processes of degradation processes in agricultural land

The analysis of the available information about the factors, condition and trends for the development of f soil degradation in arable land allows ranking by significanceof these factors as follows:

Water and wind erosion of soils:

• affects the largest areas: water erosion – approximately 3,730,000 ha (65% of the area of cultivated lands) and wind erosion – approximately 1,350,000 ha (24% of the area of cultivated lands);

• the trends for its development depend by natural conditions and are intensified by economic conditions;

• a trend for increasing erosion of farmland soils is emerging if the current manner of farmland management is preserved, along with a trend for increasing annual erosion by precipitation and wind.

Soil contamination:

• the old pollutions of agricultural lands by metals and metalloids localized in vicinity of industrial objects continue to generate hazard for humans, animals, plants and groung waters in the impacted areas;

• there is a tendency the of contaminated soils not to be increased;

•during the recent decade the agricultural practices do not lead to new loads of soils with pollutants;

•decreasing use of mineral fertilizers and pesticides during last 10 years restricts and/or minimizes the risk of deffuse contamination in the country.

Organic matter decline and soil compaction:

•degradation processes directly connected to soil erosion but without available data, considered by indirect assessment to affect much of the arable land;

• the processes should not be neglected as they determine soil fertility;

•delineated perspective to increased intensity of degradation of bothsoil organic matter and soil structure of agricultural lands if maintaining the present manner of land management;

Loss of biodiversity:

• it is associated with the processes erosion, dehumification and soil structure degradation, landscape changes causing loss of natural habitats as well as the arson of the stables;

• delineated perspective to accelerated processes of loss of biodiversity if maintaining the present manner of land management;

Secondary acidificated soils:

• affects about 1 500 000 ha, approximately 67,500 ha of which are with acidity which is harmful to the plants;

• delineated perspective to neutralization of soil exchangeable acidity in anthropogenically acidified soils with reduced application of acid nitrogen fertilizers;

• delineated perspective to modified acid-alcaline equilibrium in soils associated with increased content of exchangeable hydrogen and aluminium and severe reduction of the content of basic elements in soil with intensive appearance of soil erosion and fertilizers with acid mineral fertilizers.

Soil salinization:

• affects approximately 35,500 ha while the area and the degree of salinization depends on the climatic, hydrological and economy conditions;

• delineated perspective to reduced degree of salinization in regions with properly functioning drainage systems;

• salinization due to anthropogenic reasons tends to extention.

Recommendations and trends toward restriction and overcoming of degradation processes in agriculture

Limitation and overcoming of the degradation processes in farmlands is possible by implementation of good farming practices including a set of measures for soil protection and runoff reduction efficiency for integrated soil and water conservation specific with respect to the soil, climate, topographic, and landscape conditions aiming at:

- ensuring protective cover of the soil surface by vegetation or plant residues during the periods of high rainfall and wind erosivity;
- increased the soil infiltration capacity;
- maintaining and restoring the soil structure;
- maintaining and increasing of the soil organic matter reserves;
- using machines and technologies for soil tillage with minimal ground presure;
- using plant residues from crop rotation for briquettes, incineration in special ovens, use as raw materials for various industrial processes, etc., instead of on-site burning;
- eliminating the conditions for a secondary salinization (irrigation using highly mineralized groundwater, natural or human caused deterioration of the drainage of intensively irrigated terrains, unsuitable land use structure, which is not consistent with the particular soil and hydro-ameliorative conditions)

- removing the conditions for anthropogenic soil acidification;
- removing the conditions for soil loading with heavy metals and metalloids (plant protection chemicals, irrigation water, sewage slugs, etc.)
- decreasing the concentrations of HMM in highly polluted soils through application of appropriate technologies remediation including bio/phyto remediation.