Soil Degradation
Causes and Solutions
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Directly or indirectly, soil satisfies almost every human need for such resources as food, clothes, shelter or other essential needs for life. Soil is the source of numerous nonrenewable resources. Its role especially grows, when the need is faced to substitute the non renewable resources by renewable ones. Regardless the high levels of development achieved, the dependency on soil resources not only will decrease, but increase.

The quality of soil in Georgia is deteriorating. The primary causes are: erosion, pollution, secondary waterlogging, salinization, opencast mining of useful fossils and construction materials, unsustainable agricultural activities, unsustainable management of pasturelands and others.

Soil protection and maintenance of its fertility is an essential concern of our country, since in Georgia the sustainable use of soil resources is the main reserve for development of agriculture and economics and prerequisite of living in sustainable environment.
Soil and Its Fertility

Soil is friable upper layer of lithosphere, which is characterized by fertility. Soil provides plants with water, heat and nutrients, determining the yield of agricultural crops.

Soil fertility is mainly connected to the percentage of humus content in it (from 1-2% up to 12-15%, in upper layers of soil) consisting of organic as well as mineral substances in a readily available form for plants.

Humus layer enriched with organic matter improves the structure as well as the resistance of soil against erosion. Moreover, humus layer supplies plants with necessary water (moisture), nutrients (nitrogen, phosphorus, potassium) and microelements for a longer period.
Land Degradation and Its Causes

<table>
<thead>
<tr>
<th>Soil Degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil degradation (physical, biological, chemical) is unfavorable process, resulting in the soil losing its organic matter - humus accumulated earlier, leading towards decrease of soil fertility with 55-65% and therefore reducing its economic value.</td>
</tr>
</tbody>
</table>

**Natural factors contributing to soil degradation are as follows:**

- Relief
- Climate
- Absence of vegetation
- Character of soil/composition etc.

**Anthropogenic factors contributing to soil degradation are as follows:**

- Unsustainable tillage (frequent, incorrect) of soil
- Unsustainable grazing of pastures
- Burning of pastures and agricultural land
- Chaotic construction of settlements
- Erosion
- Intense use of pesticides and fertilizers, etc.

Proper soil management is a basis for society’s long term social and economic development.
**Agro Ameliorative Measures of Degraded Soil**

**Crop Rotation**

<table>
<thead>
<tr>
<th>Crop Rotation</th>
<th>Varying the crops within a definite timeframe and location according to predefined agricultural plan.</th>
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</thead>
</table>

Crop rotation is accompanied with the relevant soil tillage and fertilizing system. This process is effective, when properly planned and sequentially performed. Crop rotation should be planned gradually considering certain conditions:

<table>
<thead>
<tr>
<th>I stage</th>
<th>Identify the plots characterized with the same size and productivity for crop rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>II stage</td>
<td>Identify the plots for fodder cultivation</td>
</tr>
<tr>
<td>III stage</td>
<td>Identify commercially profitable crops</td>
</tr>
</tbody>
</table>
| IV stage | Considering the major principles of crop rotation structure formation throughout the crop distribution process:  
  - Incorporating intermediate plants  
  - Incorporating legume  
  - Using root vegetables  
  - Rotation of autumn and spring - ripening grain crops |

**Crop rotation contributes to:**

- Increase in yield
- Maintaining and increasing of soil fertility
- Regulating pests, diseases and weeds
- Creating food base for livestock
Agricultural measure of ploughing the green mass of specially planted crops (mainly legume) in the soil to increase its fertility.

Green manure can be used for all types of soil and crops.

The plants grown for green manure should be ploughed in soil during the phase of germinating flowers and green pods and 20-30 days before planting the following crops, as decomposition occurs faster within this period.

Green manure has beneficial influence on such soil features as:

- Enriching with nutrients
- Improving structure
- Suppressing weeds
- Increasing plants’ capacity of frost-resistance, etc.
Biochemical process enabling solid organic waste to be transformed into humus-like product. The mass resulted after composting process can be used for soil fertilization purposes.

**Composting**

- Cow and poultry manure
- Feather
- Organic food waste
- Fruit tree and vineyard chop offs
- Ash
- Straw
- Paper
- Grape husks, etc.

**Organic materials necessary for composting:**

**The following must not be used in composting:**

- Plants that are diseased or heavily infected by the pests, as they may contain the organisms or eggs causing the disease
- Plants infected with fungal disease
- Poisonous plants (oleander, hemlock, hebdane, thorn-apple, castor-plant), containing large amounts of alkaloids that kill the living organisms inhabiting in the soil
- Plants characterized by high levels of acidity (pine needles)
- Cat and dog excrements, which may contain pathological micro-organisms
In order to improve soil’s physical features, it is recommended to add 2.5 - 5 cm layer of compost to 15 - 20 cm of loosened soil. Less amount of compost can be used for sandy soil and more for clayish soil.
Mulching

<table>
<thead>
<tr>
<th>Mulch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic or inorganic material, used to cover the land surface that influences physical, biological and chemical processes occurring in the soil.</td>
</tr>
</tbody>
</table>

Mulch improves agrophysical characteristics of the soil as well as protects it from the erosion. Mulch prevents the soil from crust formation, evaporating large amount of moisture and from erosive processes caused by surface runoff.

Nowadays mulching is a widespread technique used in case of annual and/or perennial crops, as it increases soil’s humidity up to 9% and meanwhile decreases the temperature with 1.5–7.5°C degrees.

The following can be used for mulching:

- Chopped peat
- Burned organic material (burned manure, mature compost etc.)
- Straw of grain crops
- Fallen leaves
- Sawdust
- Grass
- Polyethylene
- Cardboard, paper and other organic and inorganic materials
1. Mulching is crucial for dry soil

2. Mulching can be used for crops such as: rape, mustard, vetch, strawberry, peas and etc.

3. Collecting essential materials for mulching: leaves, grass, stubble, straw

4. Covering crops with the materials collected

5. Examining the soil humidity
Soil Salinization and Fight Against It

Soil salinization is caused by salt accumulation on the land surface as a result of groundwater uplift and evaporation. The problem is characteristic to Kvemo Kartli, Kakheti and Alazani Valley. The soils covering these areas naturally contain various types of easily dissolving salts, however, the intense secondary salinization is stimulated by anthropogenic activities, in particular, incorrect land melioration and exploitation.

Selecting appropriate agricultural crops is highly important when dealing with these types of soils, e.g. grains- barley and rye (up to 0.5% of salinization). Throughout vegetables, asparagus and onion tolerate 0.6% of salinization. Pear, fig and olive plants are also characterized with the resistance to saline soil.

In order to prevent salinization, during the summer period, after the crops are harvested, soil should be ploughed to decrease the level of evaporation.
Soil Erosion and Fight Against It

| Soil Erosion |
The process of displacement of upper, the most fertile layer of soil |

| Causes of soil erosion are: |
| • Soil tillage disregarding the proper techniques |
| • Unsystematic usage of slopes |
| • Selecting wrong crops |
| • Use of inappropriate agricultural mechanisms |
| • Thinning out the vegetation protecting land surface |
| • Intense use of pasturelands and overgrazing |
| • Unsystematic cut down of the forest |

There are three main types of erosion: water, wind (aeolian) and geologic erosion. According to the development and intensity characteristics, the area of Georgia is divided into the following soil-erosion zones:

I – Western water erosion development zone of Georgia
II – Eastern wind erosion development zone of Georgia
III – Eastern water erosion development zone of Georgia
IV – Eastern wind and water erosion development zone of Georgia
V – Kolkheti Valley
Soil Protective Crop Rotation

Crop rotation gives the opportunity to improve the productivity and quality of agricultural crops, as well as to improve the quality and amount of fodder for livestock.

Perennial grasses are the best soil protectors against erosion. They improve the structure of soil, its fertility and resistance towards erosive processes. In order to restore the fertility of intermediately or highly eroded soil, the presence of mixed perennial grasses is needed during 3-4 years.

Terracing

Terracing is one of the effective measures against erosion. The presence of terraces practically prevents surface runoff. The best structure for perennial crops is stepped terraces.

- Terraces are generally constructed on the slopes of more than 45 degree inclination
- The surface area of a terrace depends on inclination degree of the slope
- Each end of the channel should be closed by the soil
- Each terrace ends with ridges

Picture 3. Terracing
Agroforestry

The intensive washing out processes are notable on the slopes covered with annual plants leading toward decline of soil quality over the time, thus becoming unsuitable for agricultural use. In order to protect soil against erosion, the agroforestry approaches must be adopted within these types of territories, involving planting of soil protective forest strips along the ravines, valleys and other erosive areas (as well as along river floodplains).

Buffer Strips

Incorporating buffer strips e.g. composed by perennial grasses, are one of the best measures to protect soil against water erosion, especially when slopes are covered with cultivated crops. The role of buffer strips can be identified nearly same as within the process of contour farming.

Buffer strips can be composed of annual as well as perennial grass, shrub and tree vegetation (raspberry, currant, gooseberry, bilberry, nuts, etc.).
Agrotechnical Measures

Because of biological characteristics, at the beginning of vegetation period, annual agricultural crops, cannot protect the soil from erosive impacts of heavy rains and surface runoff. Therefore, within exactly this period, such soil protection measures should be undertaken as deep loosening of soil, furrowing of the area surface and arranging intermittent beds. On the inclined slope, for instance in case of maize crops, the soil fillings can be done at the bottom of the maize plant instead of arranging intermittent beds. This technique holds the water within the deepened areas resulting in enhancing the soil water filtration and drainage capacity.

Drainage Ditches

Constructing the drainage ditches are considered as one of the best approaches in protecting the soil from erosion by regulating rain and snow runoff. Within the upper as well as throughout the various parts of the agricultural land the drainage ditches should be arranged as required and the ends connected to waterways or channels diverting the water to rivers, streams, ravines and others. Within the inclined areas, the ditches and channels must be covered with standard piles or rocks.
Irrigation Measures

For watering not to cause irrigation erosion, the special approaches, techniques and regimes must be used avoiding the formation of surface runoff. Irrigation erosion is intense in case of furrow irrigation form. Moreover, it is unfavourable to cultivate the crops on the same area differing in watering regimes and norms. In order to reduce the erosion intensity, both types of irrigated and non-irrigated areas, must be ploughed/sowed perpendicular to slope.

The vital approaches to reduce the irrigation erosion intensity are as follows: sprinkle irrigation, drip/trickle irrigation and so call subirrigation. These irrigation approaches practically eliminate the occurrence of irrigation erosion.

Windbreaks

Planting windbreaks is one of the best soil protection approaches. Currently, the windbreaks are planted from three to four rows having different canopy levels. The layer of tall and massive trees restrains the first airstream, followed by the layers of various trees and shrubs of different size. Windbreaks constructed using upper mentioned methodology can reduce the wind speed by 65-70%.
It is vital to arrange the windbreaks using the species characterised to a given region. The recommended species are as follows:

- Almond-tree (Amygdalus communis)
- Hackberries (Celtis caucasica)
- Oleaster (Elaeagnus angustifolia)
- Pine (Pinus eldarica)
- European ash (Fraxinus excelsior)
Sustainable Management of Pesticides and Fertilizers

Within the cultivation process of various crops, modern agriculture uses industrial technologies, resulting in intensive application of pesticides and fertilizers. Unsustainable use of pesticides and plant protective other chemicals as well as inorganic/mineral and organic fertilizers highly contaminates the environment, leading towards soil and air, plant and animal products, drinking and irrigation water pollution and degradation oftentimes causing not only intoxication and diseases but also lethal outcome.

To solve the above mentioned problem, the dosage, transportation, storage, sell, waste disposal and safety measures must be strictly regulated. Furthermore, the careful selection of chemicals to be used, is highly important.
Harmful Practice of Field Burning and Its Prevention

Nowadays fires represent the continuous threat and damage to pasturelands as well as windbreaks and protected areas. The fires are often caused by the harmful practice of field burning conducted on the private territories. This process not only destroys the upper-soil vegetation but also causes the irreversible damage to soil humus layer inhabited by rich micro flora and fauna.

One of the reasons of field burning is to reduce expenses and minimize workforce needed. In order to avoid latter, during the harvest process, combine header must be maximally lowered to grasp as much plant mass as possible and minimize the loss. Furthermore, after harvesting, the territory can be re-ploughed. It is favorable to conduct this procedure during August or the first half of September to suppress the weed dispersal. This practice is widely accepted abroad.

Sustainable Management of Pasturelands

Intensive use of pastures is one of the causes of land degradation. In order to reduce the negative outcomes resulted from grazing, the pasturelands must be managed sustainably. From the financial as well as ecological viewpoint using the surface measures throughout the improvement process of pastures is more beneficial.

The completion of grazing season should be followed by systematic grass mowing using mechanical forces (5-6 cm. height). This approach is effective in fighting against the dispersal of weeds and plants with low nutrition value, as well as promoting the formation of new roots and leaves, increasing the grazing potential and quality of grasses.

It is favorable to use organic fertilizers in order to enrich the pasturelands, e.g. manure, peat and compost. Fertilizers can be applied mechanically. Furthermore, the use of manure spreader agricultural machinery is recommended ensuring equal distribution of the manure within the surface.
In order to avoid the long-term and continuous grazing on a certain area, the regulated grazing system approach can be used, considering restriction of grazing periods and areas during the field/pasture rotation.

The pasture rotation is highly important which refers to determining the terms and usage frequency, grazing and mowing, grazing and resting, using after seed germination and rotation of grazing seasons on the annual basis. The rotation of pasture usage terms is conducted according to the rotation of the annual beginning of field grazing. On a highly tamped and degraded grazelands, the grazing is restricted for one or couple years and only after the restoration, the pasture can be gradually used.

Considering the total area of the pastureland and the number of animals, the pasture rotation can be:

1. Large-scale - when the pasture is divided into 4 or maximum 6-8 plots and the grazing duration on each of them is 4-8 days
2. Small-scale - when 12-36 plots are allocated and each of them is used for 1-3 days

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Glossary

Soil – the upper fertile layer of the Earth, formed as a result of long-term interaction of soil forming factors.

Crop Rotation – rotation of crops within the same area according to the predefined schemes, with the participation of leguminous crops.

Anthropogenic Impact – impact on soil done by human activities.

Humus – a combination of specific and non-specific organic substances in the soil, a dynamic complex of organic compounds resulted from the decomposition and humification processes of organic waste.

Soil Type – the major taxonomic unit of soil classification.

Soil Fertility – the main and essential feature of the soil, which distinguishes it from the parent material and is considered as the precondition for crop yield.

Erosion – removal and translocation of upper layer of the soil resulted from various natural or anthropogenic factors.

Using Green Manure – agricultural measure of ploughing the green mass of specially planted crops (mainly legume) in the soil to increase its fertility.

Compost – organic fertilizer enriched with various organic and mineral substances, containing all the necessary materials for the plant growth and development.

Mulch – material (organic or inorganic) that can be used to cover the soil surface.
About this publication

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