Proceeding the Economic Dimension of Land Degradation, Desertification and Increasing the Resilience of Affected Areas in the Region of Central and Eastern Europe (EDLDIR-2013). Mendel university in Brno press, Czech republic 2013, ISBN 978-80-7375-715-1.

Brief Outline Of Soils In Armenia

Hunan Gh. Ghazaryan

Scientific Center of Soil Science, Agrochemistry and Melioration after H. Petrosyan" Branch of National Agrarian University of Armenia.

ABSTRACT

Fourteen major soil types, 27 semi types, and total of 228 soil groups have been studied and highlighted according to the natural-soil zones in the territory of Armenia. Their dissemination areas, the main soil characteristics, soil formation specificities, and international names have been provided; the schematic cartogram of natural-soil zones and the soil map have been formed. The paper considers the negative consequences of desertification phenomena taking place under the influence of global climate change, the soil degradation forms, adaptation programs, and approaches on mitigation.

Key words*: natural-soil zone, soil type, desertification, degradation, climate change, erosion, productivity.*

INTRODUCTION

Armenia has an area of about 30 thousand km^2. Mountains make nearly 70% of the country's territory. The average altitude is 1,800 meters above see level. About 90% of the territory is located above 1,000 meters.

RESEARCH METHODOLOGY

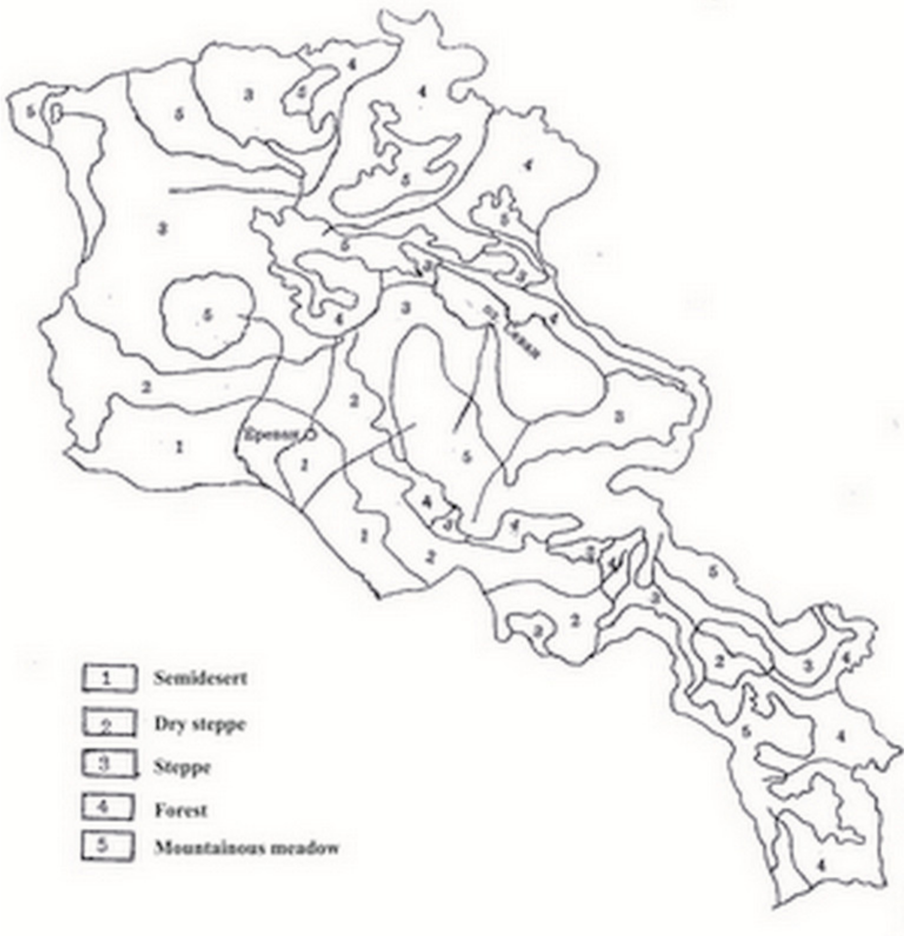
The soil degradation criteria and methods of their study have been explored and are now being clarified. In particular, to obtain the accurate picture of the soil cover, the following research methods should be applied:

- The key method of soil research, according to which complete soil cuttings are put at typical spots in a particular area.
- The method of semi-holes, which are made for data clarification, as well as for identification of the boundaries of dissemination of the observed indicators.
- The statistical-comparative method, which helps compare data received previously and the present data.
- The visual method, when the soil cover is assessed by its current appearance.
- The laboratory method applied to obtain the correct physical and chemical properties of soils.

***

Nearly all zonal soil types that are developed not only in the region of Lesser Caucasus and the Armenian Volcanic Plateau but also in the mountain system of the Greater Caucasus, are available in Armenia's territory. The great diversity of bioclimatic and lithological-geometric conditions as well as the long and diverse economic activity have led to formation of different soil types, the most common types being mountainous-meadow (Leptosols), mountainous meadow-prairie (Phaeozems), mountainous brown forest, mountainous cinnamonic forest (the last two types, together with the forest humus-carbonate types are joined in the large soil group of Cambisols), mountainous black soils (Chernozems), mountainous chestnut (Kastanozems), and mountainous brown semidesert soils (Calcisols) (see Map 1). In addition to the zonal soil types, in the territory under consideration intra-zonal soil types also are developed; these are soils that can be available in different soil types. The intra-zonal soil types include: bottomland-marshy, bottomland-meadow, meadow-brown irrigated (crop-irrigable), meadow-blacksoil, sod-carbonate, alkaline paleohydromorphic, saline-alkaline hydromorphic, etc. Overall, Armenia has 14 types, 27 subtypes, and a lot of families, varieties and species of soils. The total number of soil differences is 228.

MAP 1. SOIL-BIOCLIMATIC ZONES OF THE REPUBLIC OF ARMENIA



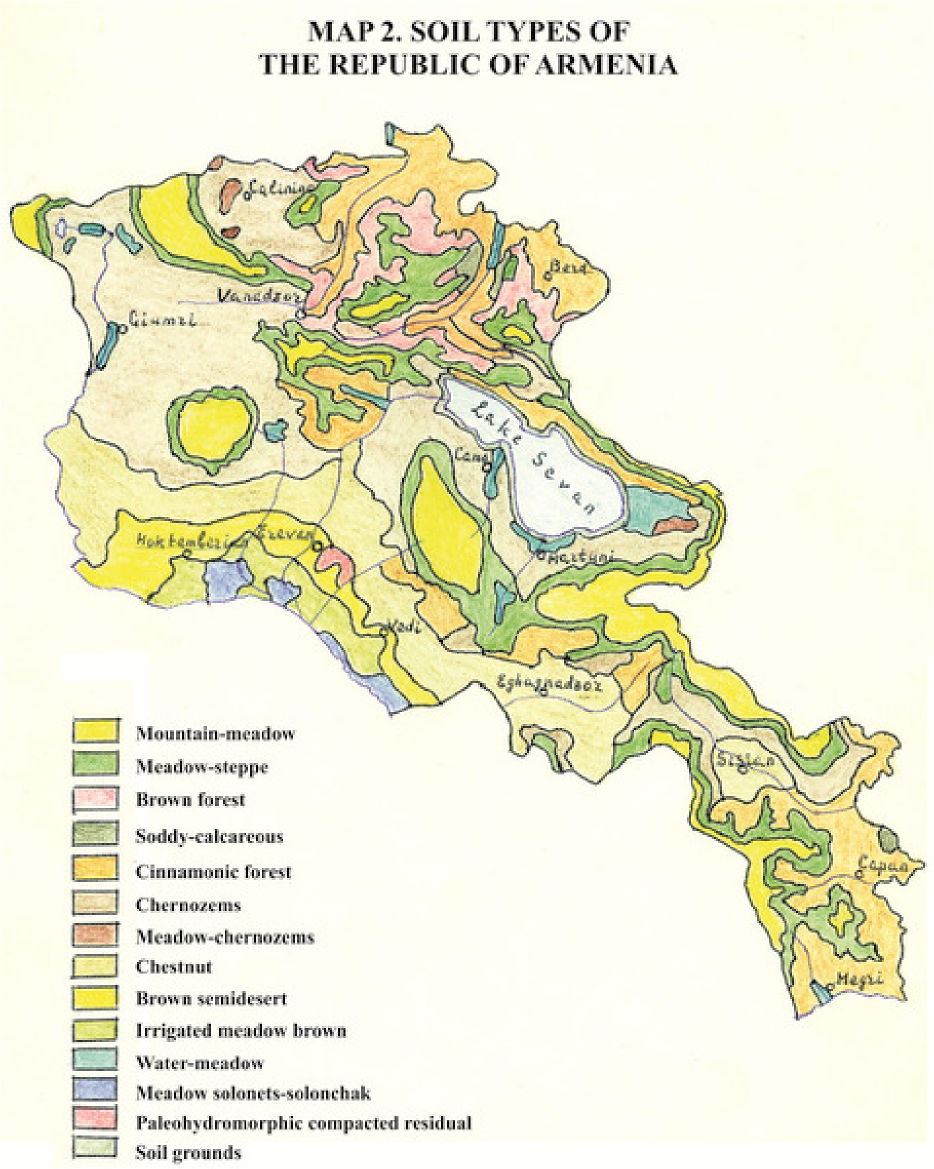
The general characteristics of natural-soil zones of Armenia are brought up in Table I.

Table I. Natural-soil zones and soil types in Armenia

Natural-soil zone	Soil types	RSG (respective soil group)	Territory		Altitude m a.s.l.
			Thousand ha	%	
Semidesert	Semidesert brown	Calcisols	152.0	5.8	850-1250
	Irrigated meadow-brown	Antrosols	53.0	2.0	
	Paleohydromorphic	Solonetz-Solonchaks	2.0	0.1	
	Saline-alkaline hydromorphic	Solonetz-Solonchaks	29.0	1.1	
Dry-prairie	Mountainous chestnut	Kastanozems	242	9.2	1250-1900
Prairie	Mountainous blacksoils	Chernozems	718.0	27.4	1300-2450
	Meadow blacksoils	Chernozems	13.0	0.5	
	Flood-plain – terraced	Antrosols	48.0	1.8	
	Groundsoils of Lake Sevan	Regosols and rock outcrops	18.0	0.7	
Forest	Mountainous-brown forest	Cambisols	133.0	5.2	500-2400
	Mountainous sod – carbonate forest		15.0	0.6	
	Mountainous cinnamonic forest		564.0	21.6	
Mountainous - meadow	Mountainous - meadow	Leptosols	346	13.2	2200-4095
	Mountainous - meadow prairie	Phaeozems	283	10.8	
Total area			2616.0	100.0	

In addition to the soil types listed in Table I, another 358,000 hectares of the country's land make the ledge rocks, sands, objects of infrastructure and residential zones.

In the semidesert natural-soil zone, brown semidesert soils are disseminated in a narrow strip in the lowland part of Ararat basin where they represent the bottom level of vertical soil zoning (See Map 2). Dry continental and hot climate, thin vegetation cover and rich foundations of lava deposits have led to formation of underdeveloped, low-capacity, deeply gypsiferous soils with rubbly-stony carbonate profile, where the relief is mainly represented by hilly-wavy lava plateau; the erosive-denudation type of relief is also available. Soil-forming rocks are represented by eluvial, eluvial-dealluvial, rubbly, fragmental-rubbly, calcareous soils, often plastered with loams. In the middle part of the soil profile, there are well-formed illuvial-cemented horizons. Poor humus content and light mechanical composition make the soils receptive to development of natural and anthropogenic erosion expressed by wide dissemination of eroded soils. The mainly brown semidesert soils of Armenia are non-alkaline and have well-formed carbonate horizon and light mechanical composition of soil rocks.



MAP 2. SOIL TYPES OF THE REPUBLIC OF ARMENIA

Among intra-zonal soils, irrigated meadow-brown soils are largely disseminated in the semidesert natural-soil zone; they occupy the lowest (800m-950m) sloping-plain part. These soils have been formed on quaternary pebble-sandy and sandy-loamy deposits. As a result of the impact of continuous irrigation, meadow-brown soils have formed a powerful agri-irrigation horizon characterized by high biological activity. Currently, part of these soils do not have ground nutrition and have switched to automorphic development regime. The rest of irrigated meadow-brown soils is characterized by semi-hydromorphic water regime. These soils indicate deep salinization.

In the dry-prairie natural soil zone, mountainous-chestnut soils are spread; they occupy the average (1,250m-1,900m) levels of the Ararat basin, Arpa cavity and the territories of wavy sloping plateau and stubs. Mountainous chestnut soils are formed in conditions of insufficient humidity, comparatively warm and dry continental climate, under the cover of fescue vegetation, with a considerable participation of xerophyte.

Mountainous chestnut soils, formed on weathering products of lava rocks are distinguished by rubbliness, medium-loamy mechanical composition, and presence of carbonate cemented horizon. Over 60% of the area of mountainous chestnut soils have been exposed to erosion.

Part of mountainous chestnut soils were formed after disappearance of forest vegetation on weathering products of sedimentary-volcanogenic deposits. These soils are characterized by mellow composition, light rubbly-stony mechanical composition and absence of cemented horizons. About 80% of the area of mountainous chestnut soils are eroded.

In the prairie natural-soil zone, mountainous blacksoils (zonal type), as well as meadow-blacksoils, flood land-terraced soils (inta-zonal types), and Lake Sevan soils are developed.

Mountainous blacksoils of Lori prairie, Shirak plateau, and Aparan array formed on lake deposits have a hydromorphic origin. As a result of further steppification, soils obtained properties characteristic for soils of prairie group. These properties serve a bases for separation of subtypes and species.

Modern regular carbonate mountainous blacksoils were formed on weathering products of the basic and medium (neutral) lava deposits. The soils have mainly rubbly-stony granulometric composition. In some regions located on lower altitude and warmer climatic subzone, regular carbonate mountainous blacksoils demonstrate illuvial-cemented horizons.

It is significant that blacksoils having post-forest origin (Tegh, Gugark and partially Lori arrays) are distinguished by mealy-micellar forms of carbonates. Mountainous blacksoils formed under prairie vegetation display mealy and mealy-dotted forms of carbonates.

A considerable part of mountainous leached blacksoils developed in pre-peak positions of knolls and hills are distinguished by abundance of fragmental-slaggy matter in the soil profile. These soils are characterized by carbonate bedding close to the surface. In their development, mountainous leached blacksoils gradually evolve into deeply profiled soils having lowered depth of carbonate occurrences.

About 80% of mountainous blacksoils occupying sloping plains and inclined slopes are characterized by heavy silty-pulverescent composition and are normally slightly eroded.

Among mountainous blacksoils on pre-terraced territories and lowlands having ground nutrition, meadow-black leached soils and – less often – calcareous soils are formed.

The forest natural-soil strip occupies the medium and lower (500m-2,400m) mountainous part of the Lesser Caucasus ridge. The zonal types of this strip are brown forest and cinnamonic forest soils. Intra-zonal soils are represented by turfy-calcareous soils.

Brown forest soils occupy the north-eastern part of Armenia. They are formed under beech-hornbeam forests that are here and there modified. Depending on hydrothermic conditions and the composition of soil-forming rocks (acid or neutral), two soil subtypes are formed: brown forest strongly unsaturated and brown forest weakly unsaturated soils.

As a result of economic activity (grazing and felling), brown forest soils of the upper zone of forests have been considerably modified and degraded. The steppification process leads to development of turfy process and formation of mountainous-meadow soils. Evolution of soils in forest territories leads to the development of features of blacksoils.

Cinnamonic forest soils are formed under the cover of xerophytic deciduous forests, in the composition of which, Georgian, Oriental, and Araks oaks, oriental hornbeam, field maple, and junipers are predominating. We consider the availability of brown tones in the profile of cinnamonic leached soils as relict indications inherited from the preceding brown soil formation process.

Changes in the forest cover and the economic usage of soils in the forest zone have led to a significant change in the soil properties. This in turn led to the necessity of revising the soil classification, revealing new families and species of soils and subsequent change in the boundaries of soil subzones.

The mountainous-meadow natural-soil zone occupies mountainous arrays located higher than 2,200m a.s.l. and is represented by two genetic soil types: mountainous-meadow and mountainous-meadow-prairie.

Mountainous-meadow soils occupy the highland part of the Armenian Volcanic Plateau and the Lesser Caucasus within the range of 2,200m-4,000m. These soils are formed in conditions of cold, often severe and humid climate under alpine and sub-alpine – predominantly humid and mesophilous – meadows, where dwarf cereal-grass and grass-cereal-legume crop groups are developing.

For the mountainous-meadow zone, the following are characteristic: short vegetation period with high precipitation, significant fluctuation in temperature and air and soil humidity. Year-around excess humidification (with humidification coefficient of 2.0-2.5) creates continuous wash regime that contributes to removal of soil-forming products from the soil profile.

The territory of mountainous-meadow soils is unequal, which is explained by difference in ruggedness of relief. On more slanting and well-moistened slopes and watersheds, fully developed soils with dense turfy layer are disseminated; while on the slopes of southern exposition, soils with underdeveloped rubbly profiles are developed.

Mountainous-meadow soils are distinguished with strong acid reaction (pHKCI 3.8-5.3), low exchange capacity, high content of humus in the upper horizon which abruptly goes down depending on the depth.

Mountainous meadow-prairie soils are formed on the average height zone, on the elevation of 2,200m-2,700m and make up transition soil zone between the mountainous-meadow subalpine soils and mountainous-prairie or forest-prairie soils. The following are characteristic for formation of these soils: weak continentality of climate; availability of meadow-prairie and subalpine vegetation; and concentration with alkalis of soil-forming rocks.

Mountainous meadow-prairie soils are represented by two subtypes that are distinguished by conditions of formation as well as by morphological and physical-chemical indicators. Soils are characterized by well-defined cloddy-granular structure, high content of humus, and weak-acid reaction.

Overall, the territory of the meadow-prairie zone is used for haymaking and as pastures. In some places soils are plowed and used for growing potatoes, barley and perennial grasses.

A brief analysis of the conditions of development and distribution of soils indicates that in the territory of Armenia a large diversity of soil types and subtypes have been formed which have specific morpho-genetic, chemical, biological, and other peculiarities. The dissected diversity of soils is explained not only by interactions of unique combination of bioclimatic and lithological-geomorphologic conditions of soil formation, but also is specified by the historic and diverse economic usage of soils. In a number of cases, the anthropogenic factor appears to be the leading one in the modern evolution of the country's soils.

Based on the above-mentioned, we can state that the geological position of Armenia, its well-expressed vertical zoning, the fragmentation of the mountainous relief, active external processes, scarce land resources and unsatisfactory land moisture rank the country among the extremely risky countries from the agriculture perspective.

The riskiness of agriculture increases due to the little land resources (0.14 hectares of arable land per capita) and the extreme fragmentation of land (340,000 farms, over 1.2 million land plots). Around 80% of the land resources are characterized by desertification characteristics and by different degrees of soil degradation. Degradation of the soils is having a great negative impact on soil productivity and accumulation of organic carbon in soil.

The next important issue is the loss of organic carbon (humus) due to the intensive agricultural activity. The inefficient use of agricultural lands over the course of the recent three decades has entailed about 50% loss of carbon (humus). Temperature changes in Armenia are unambiguously grounded by the global climate change, which is complemented by the impact of internal anthropogenic microclimatic changes, which in turn will be used to assess the sensitivity and vulnerability of a particular asset (including land).

First of all, it should be stated that ensuring high yields in agricultural lands with non-irrigated farming practices in water-short Armenia, especially impacted by global climate change, almost totally depends on the availability of soil's effective amount of moisture. Soil moisture is sensitive to both air temperature and amounts of precipitation, which are interconnected by multifactor linear links. In this regard, temperature rise due to climate change and decrease in precipitation will result in 10-%-30% reduction of the available stocks of water in soil.

To ensure high yields, it is critical to study the dynamics of effective soil moisture during the vegetation period, which will enable to have an idea about the water regime of the soils in a particular area, define irrigation and watering norms and the time and methods of the application thereof.

Since the main amount of precipitation in Armenia occurs during the period of late fall-winter-early spring, therefore temperature rise by 1.5-2.0°C and 10%-12% reduced humidity during the beginning stage of plant vegetation period in spring, will not have any essential impact on the effective soil moisture.

Shortage of available soil moisture will be considerable in summer and early fall, especially during winter sowing; therefore there will be a need to increase irrigation norms and more frequent watering to complement the effective water amount in soil and to meet the water demands of plants.

All this will result in increase of required amount of irrigation water up to 100-120 million m³; otherwise precipitation and temperature changes in Armenia will result in higher degree of vulnerability of soils and decrease in the yielding capacity of crops.

Land is the only natural resource in the country that is privatized, and the formerly state-managed land use is now privately managed, thus making it difficult to find regulated complex solutions to many problems.

The global climate change and the land use management system have created the following problems as to land resources:

1. Land degradation
2. Land pollution
3. Landslide, land movement and rock fall
4. Poor land management

All these problems are interconnected; however they are not distributed equally across the country. An example of interconnected factor is decrease in the soil productivity which can be a consequence of erosion (washing of nutrients). The low soil productivity contributes to occurrence of scarce and thin plant cover. Another case is when, due to soil degradation, strengthening of topsoil causes poor water filtration, which in turn strengthens water erosion, occurrence of floods, as well as more hearths of landslide, which are developing especially in the steep slopes in mountainous regions of the country (characteristic to the southern slopes), while in lowland regions (Ararat Valley), salinization-alkalization and over-humidification of land are among the main problems within the semidesert climatic zone.

In this regard, the climate changes endanger the overall agriculture sector in the country. As a consequence of the forecasted temperature rise and reduction of precipitation it is expected that in the years to come (2030, 2050, 2070, 2100) the evaporation from soil will be strengthened, the area of secondary saline-alkaline soils will increase, downpours and floods will occur in certain times of the year, the natural humidity of soil will decrease by 10%-30%, and non-irrigated agricultural lands will decrease.

All the above mentioned phenomena can contribute to increase of plant diseases and pests and enlargement of their dissemination area.

Degradation trends are noticed also in natural pastures, especially considerable in the neighborhood of settlements, which is largely a result of inaccessibility of distance pastures as well as forced changes in grazing practices (early beginning of and late ending of grazing) linked with insufficient feed supplies for winter.

Impacted by the global climate change, undesirable changes are taking place, of which, in terms of land resources, the following could be highlighted with regard to land degradation:

1. Decrease in potential and effective land productivity. As a result of decrease in the amount of biomass applied to soil at the end of vegetation period and rapid use of organic carbon (humus) supplies existing in soil, the organic carbon of soil is dramatically decreased.
2. A decomposition of the soil's structure and decrease in the amount of waterproof aggregates are taking place, which results in increase of powdered mass.

3. As a result of lower precipitation and higher temperatures, evaporation of humidity from soil increases, which, first of all, decreases the amounts of effective humidity necessary for plants and the natural moisture rate.

4. Because of powdered soil, activation of erosion (water, wind and road) processes takes place, which results in depriving the topsoil of the richer and more tender fractions.

5. After washing of fine soil as a result of erosion processes, the amounts of stones and rubbles predominate in the soil cutting, which later have a negative impact on the cultivation efficiency.

6. The slopes, especially those of southern exposition are becoming bald (badland) and are completely losing the vegetation.

7. Because of hardening of the subsoil and powdering of the topsoil, as well as the deforestation in the forest lands, the areas of landslide hearths as well as the frequency thereof are increasing.

8. Because of non calculated (excess) by land users any watering rates in Ararat Valley, the salinization-alkalization phenomena are strengthening in the area of mineralized waters.

9. During the spring melting, because of rapid melting of snow and overflow in the rivers, the lands in the valley are often flooded, which causes soaking of water and therefore rise of ground water level and, consequently, over-humidity and bogging. The latter is observed also in the lands in the proximity of fish farms.

10. Linked with changes in climatic conditions, changes in the character and direction of soil formation processes are observed, with soil formation processes typical of semidesert and desert areas predominating.

In the current phase, both state and private agencies in Armenia are trying to expand (join/consolidate) land areas and enhance their productivity, which comes across with the challenge of climate change. To meet the challenge, an optimal program for assessment of the degree of vulnerability of land resources, adapting to climate change and mitigation of its impact should be developed, taking into consideration the following factors (measures):

Adaptability: Improvement and renovation of irrigation systems or building new ones for ensuring water for plants during the dry season; planting trees for soil protection or field protection purposes to maintain the snow layer during winter and accumulation of moisture in soil and to prevent erosion; strengthening of snow layer during the gradual melting process to accumulate moisture in soil. To use the accumulated moisture efficiently, carry out control of weeds, plant new and drought resistant varieties, accumulate snow during the melting period to use later during the vegetation season, perform amelioration in saline lands, collect rocks in the pastures and accumulate them in layers in the direction of the horizontal lines on slopes to prevent the water erosion. To improve the plant cover in pastures, sow seeds of grasses with high nutrient values.

The Ministry of Agriculture should introduce drought resistant and heat resistant varieties and hybrids, disease and pest resistant varieties; reduce the load of high mountainous pastures; encourage the standardized application of fertilizers; movement of land using zone to the humid areas of the country; application of crop rotation; application of water saving irrigation technologies and moisture protection; implementation of anti-hail and anti-flooding measures; creation of insurance systems to insure against natural disasters in areas with potential flood and land slide danger as well as providing relevant financial means.

Provide timely information on the expected natural disasters, as well as timely vaccination of livestock.

Mitigation measures: it is necessary to carry out improvement of crop types and prolongation of crop rotations, involving high value and dryland varieties of perennial grasses; escape plowing of fallow lands; add nutritional matters in a systemized way; introduce zero or minimal cultivation methods; occupy the interstices between the field-protecting forest strips with annual and perennial crops; apply practices of reduction of dangerous emissions, enhance irrigation efficiency, optimal grazing of pastures (rotational grazing); cultivate cultivars with deep root system; manage the manure maintenance to obtain biogas, etc.

To mitigate the negative impact of the above mentioned phenomena and to ensure improved productivity of agriculture in such conditions, it is necessary to take into account not only the current situation but also the perspective that can be expected in the near future.

From this standpoint, we have discussed and identified issues covered in the first and second country reports on climate change within the UN Framework Convention on Climate Change, the National Action Plan to combat on desertification in Armenia prepared within the UN Convention to Combat Desertification, as well as the RA law on elimination of drought aftermaths, the second National Action Plan on Environmental Protection, Poverty reduction strategic program set out by the Sustainable Development Program, Sustainable Agricultural Development Strategy, the Action Plan of the RA Ministry of Agriculture specified by the provisions of the National Security Strategies of the Republic of Armenia, the law of the Republic of Armenia on Food Security, the problems and development strategies of the food and agriculture system in the Republic of Armenia, Statistic Yearbooks of Armenia.

The existing publications and results of scientific research have been brought together.

REFERENCES:

Targulyan, V., Gerasimov, M., (2007): *World correlative base of land resources. Background for international classification and correlation of soils*. Moscow: KMK, 278 p. *(in Russian)* ISBN 978-5-87317-381-5.

Socioeconomic impact of climate change in Armenia. (2009). Yerevan, , pp. 65-77, 114-118. *(in Armenian)*.

Gabrielyan A. (editor), (1999). *Climate change problems*. Yerevan: Gitutyun, 373 p. ISBN 5-8080-0402-0.

Address:

Porf. Hunan Gh. Ghazaryan

“Scientific Center of Soil Science, Agrochemistry and Melioration after H. Petrosyan” Branch of National Agrarian University of Armenia, Admiral Isakov av. 24, Yerevan, 0082, ARMENIA; ghazaryan_soil@yahoo.com