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ECOLOGICAL PROBLEMS

ASSOCIATED WITH LAND COVER IN THE GREAT CAUCASUS AND IMPORTANT ASPECTS FOR EFFICIENT USE

PROBLEMAS ECOLÓGICOS ASOCIADOS A LA COBERTURA DEL SUELO EN EL GRAN CÁUCASO Y ASPECTOS IMPORTANTES PARA UN USO EFICAZ

Gulnar Nuru Hajiyeva[1]
E-mail: hgulnarn@gmail.com
ORCID: https://orcid.org/0000-0002-1061-1652
Afaq Zakir Hajiyeva[2]
E-mail: afaq.adiu@mail.ru
ORCID: https://orcid.org/0000-0002-9813-7835
Firuza Mubariz Jafarova[2]
E-mail: jafarova_firuza@mail.ru
ORCID: https://orcid.org/0000-0003-1342-1843
[1]Institute of Geography of the National Academy of Sciences of Azerbaijan. Baku, Azerbaijan.
[2] Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan.

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ABSTRACT

Soil is one of the important factors in the landscape, it is the most fertile layer of the Earth and is estimated as one of the main elements for the development of agriculture. Due to the historical exploitation by different agricultural activities several areas have been impacted by the reduction of the fertile layer of soil covers. However, this problem has grown more recently. The intensification of development in the world, including in Azerbaijan and its regions has led to the loss of the original state of natural ecosystems and their components, changing the ecological environment. The latest variable of these components, but the greatest impact of the loss of fertility on the environment is soil cover. Ecological problems like decreased soil productivity, intensification of the erosion process, acceleration of degradation, and so on highlights the importance of a rational use of soil. Taking this into account the goal of this work was to analyze the importance and the sensitiveness of soil cover to accomplish a rational use as well as ways of protection in the Great Caucasus zone in Azerbaijan.

Keywords: ecosystem services, soil sensitiveness, soil protection.

RESUMEN

El suelo es uno de los factores importantes en el paisaje, es la capa más fértil de la Tierra y se estima como uno de los elementos principales para el desarrollo de la agricultura. Debido a la explotación histórica por diferentes actividades agrícolas varias áreas se han visto impactadas por la reducción de la capa fértil de las coberturas del suelo. Sin embargo, este problema ha crecido más recientemente. La intensificación del desarrollo en el mundo, incluso en Azerbaiyán y sus regiones, ha llevado a la pérdida del estado original de los ecosistemas naturales y sus componentes, cambiando el entorno ecológico. La última variable de estos componentes, pero el mayor impacto de la pérdida de fertilidad en el medio ambiente es la cobertura del suelo. Problemas ecológicos como la disminución de la productividad del suelo, la intensificación del proceso de erosión, la aceleración de la degradación, etc. resaltan la importancia de un uso racional del suelo. Teniendo esto en cuenta, el objetivo de este trabajo fue analizar la importancia y la sensibilidad de la cobertura del suelo para lograr un uso racional y formas de protección en la zona del Gran Cáucaso en Azerbaiyán.

Palabras clave: Servicios ecosistémicos, sensibilidad del suelo, protección del suelo.

INTRODUCTION

According to Hasan et al., (2020) the Ecosystem services (ESS) concept first came into view in the 1980s and since decision-makers are strongly influenced by economic data, these are usually quantified in economic terms based on their prices in a market or based on the prices of alternative (substitute) goods and services. Costanza et al., (1997) were the first to evaluate ecosystem services based on 17 service functions which were again re-grouped into 5 types afterward. However, ESS is a complex issue which integrates varied dimensions including environmental, social, economic, recreational, landscape, and cultural. Since the publication of the Millennium Ecosystem Assessment (MEA), the global interest for "ecosystem services" has rapidly grown in scientific studies and policy makers' agenda. At the international level, many initiatives—i.e., the Economics of Ecosystem Services and Biodiversity (TEEB), the Common International Classification of Ecosystem Services (CICES), and the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES)—have analyzed and incorporated the ecosystem services framework in the environmental and forestry policy targets. Therefore, in the last two decades the concept of ecosystem services has become the leitmotiv of natural resource management (Paletto & Favargiotti, 2021).

In this regard, soil is a complex system at the intersection of the atmosphere, lithosphere, hydrosphere and biosphere that is critical to food production and key to sustainability through its support of important societal and ecosystem services. For this soil health management in support of sustainability must consider three points: that enhancing many soil ecosystem services requires multifunctional management; that managing soil to improve one service can have positive (synergistic) or negative effects (tradeoffs) on another service; and that soil health management should sustain soil services over the long term (Lehmann et al., 2020).

As highlighted by Drobnik et al., (2018), intensification and competing uses of soils for cropping, forestry, pasture, and urbanization are increasingly impacting the provision of life-supporting services such as food production (Bommarco et al., 2018), clean water for drinking, flood mitigation, and habitat for plants and animals. While soil scientists have increasingly called for a comprehensive consideration of soils and their services in decision-making, soil has been usually omitted from land use decisions and is marginalized as a two-dimensional surface whose multitude of functions is not explicitly recognized (Koch et al., 2013). However, the awareness of soil importance has gradually allowed this to be a fundamental aspect in government policies and more frequently it is a topic discussed in national strategies.

Azerbaijan is an example where the importance of the soil has been well recognized by its scientists, which is why various studies on the subject have been reported. For example, Han et al., (2021) studied the spatial distribution of salinity and heavy metals in surface soils on the Mugan Plain, while İsmayilov et al., (2020) analyzed their classification among arid soils. Babaev et al., (2015) addressed soil degradation and Ismayilov and Mikailsoy (2015) analyzed the fertility of the soils of Azerbaijan via mathematical models.

Related to the above, the soil cover is one of the ecosystem's most important components, is more dynamic than other areas of the landscape and reflects all the varieties of anthropogenic effects. Unlike the other components of the geosystem, the soil cover changes its function very late and is degraded. So, it has a long-term storage ability of genetic features, productivity, fertility, and other qualitative indicators, though it is assimilated by different farm areas. Despite the mentioned indicators, over time their morphometric features change, balance, ecological balance, productivity, fertility decrease, erosion process intensifies, and degradation accelerates, and this results in aggravation of ecological problems of soils.

This process has shown itself in the soil cover of the mountain geosystems in the northeastern of the Great Caucasus. The fact that the studied area is one of the territories of the Republic has led to the intensive and spontaneous development of various farm areas and the replacement of natural geosystems with anthropogenic geosystems. Recently, the realization of great projects and agro-industrial accelerated the establishment of various ecological deterioration. Prevention of degradation and loss of soil productivity is one of our epoch's most urgent problems.

Taking the above into account the goal of this paper was to analyze the importance and the sensitiveness of soil cover to accomplish a rational use as well as ways of protection in the Great Caucasus zone in Azerbaijan. To accomplish this GIS technologies, cartography, zoning, systematic analysis, and other methods have been used in the realization of the research work. Specifically, during the investigation of soil cover in the zone, it was used a map compiled by professor G. Sh. Mamedov where space images, and granulometric indicators of soils were reported (Figure 1).

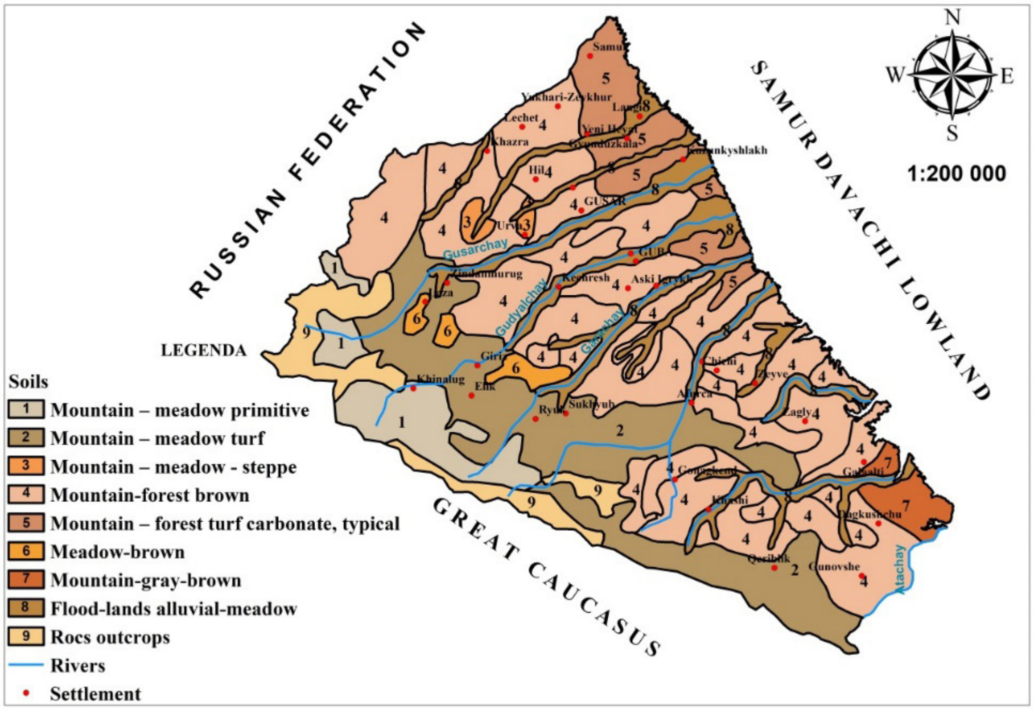

Figure 1. Map of soil types of the mountain geosystems on the north-eastern slope of the Great Caucasus

DEVELOPMENT

The soil cover of the mountain geosystems on the northeastern slope of the Great Caucasus spread according to the law of vertical zoning. Here different types of soil surround a large zone like: mountain-meadow primitive, mountain-meadow-steppe, mountain-meadow-turf, mountain-forest-brown, mountain-forest turf-carbonate, typical, mountain-gray-brown among others. As it is shown from the previous map that investigated zone is distinguished by fertile soil cover. For this reason, it is exposed to intensive assimilation by various farm areas. Such a state has caused a decrease in their nutrition, reduction of Bonitet scores, change of granulometric composition, acceleration of degradation process, intensification of erosion, and activation of negative situations (Friese et al., 2003; Von Haaren et al., 2000). For this, it is important that environmental problems do not deepen, and lands are used efficiently for their restoration.

To analyze the sensitiveness of soil, data reported by previous works (Q. S. Mammadov, 2007; Q. S. Mammadov & Khalilov, 2004; R. M. Mammadov, 2016; Marsh, 2010; Özyavuz, 2018; Salikhov et al., 2018) were used like the inclination of slopes in the zones, vertical fragmentation degree, the intensity of erosion processes, and indicators of the assimilation level of soil which is shown in Tables 1,2 and 3.

Table 1. Sensitiveness criteria of soil cover.

Soil types	Inclination of slopes	Vertical fragmentation (km/km2)	Erosion rate	Danger of erosion	Assimilation from zone
Mountain – meadow primitive	>300	High (1,5-2,1)	Moderately, heavily eroded	Very strong	Less used
Mountain – meadow turf	250-300	High (1,2-2)	Moderately, heavily eroded	Very strong	Summer pasture
Mountain – meadow - steppe	200-250	High (1-1,5)	Moderately eroded	Strong	Summer pasture, hayfield

Mountain-forest brown	150-200	Medium (0,6-0,9)	Weakly, moderately, heavily eroded	Strong	Forest (beech, hornbeam)
Mountain – forest turf carbonate, typical	100-150	Medium (0,4-0,6)	Moderately, heavily eroded	Average	Forest
Mountain-forest brown	50-100	Medium (0,5-0,7)	Moderately eroded (wind and water)	Average	Winter pasture (arable land)
Meadow-brown	50-80	Low (0,2-0,4)	Weakly eroded	Weak	Winter pasture (perennial arable area)
Mountain-gray-brown	10-50	Low (0,5-0,3)	Weakly eroded	Weak	Winter pasture (arable area)
Flood-lands alluvial-meadow	<30	Lowest (0,3-0,02)	Not eroded	Not eroded	-
Rocky outcrops	>450	High (2-3,4)	Very heavily eroded	Very strong	-

Table 2. Criteria for assessing the sensitivity of soils in terms of economic development.

Sensitiveness	Intensity of erosion processes	Vertical fragmentation degree	Inclination of slopes	Spreading of sliding areas	Assimilation from zone
High	Strong	>1,12	>250	> 100 km^2	Permanent glaciers
Middle	Middle and partially weak	1.12-0.35	10-25°	30-100 km^2	Intensively grazing pastures, arable lands. areas with a partial development of residential areas.
Weak	Not eroded	< 0.35	<10°	< 30 km^2	Crops, gardens

Table 3. Sensitiveness degrees of soil types

Soil types	For the intensity of erosion processes	For vertical fragmentation degree	For slope inclination	For spreading of sliding areas	Assimilation from zone	Sensitiveness
Mountain–meadow primitive	High	High	High	Weak	Weak	High
Mountain–meadow turf	High	High	High	High	High	High
Mountain – meadow - steppe	High	High	High	High	High	High
Mountain-forest brown	Middle	Middle	Middle	High	Middle	Middle
Mountain–forest turf carbonate, typical	Middle	Middle	Middle	High	Middle	Middle
Mountain-forest brown	Middle	Weak	Middle	Middle	Middle	Middle
Meadow-brown	Weak	Weak	Weak	-	Middle	Weak
Mountain-gray-brown	Weak	Weak	Weak	-	Middle	Weak
Flood-lands alluvial-meadow	Weak	Weak	Weak	-	High	Weak
Rocky outcrops	-	-	-	-	--	-

According to the above, the soil cover of the research zone is divided into 3 groups for sensitivity: high, middle, and weak. The soils were analyzed for sensitiveness (table 1 and 2) criteria, but their sensitiveness is defined in Table 3. As a result of our research 28,1% of soil cover on the northeastern slope of the Great Caucasus possesses higher sensitiveness. The spreading of the mentioned lands mainly in high mountainous areas causes their lack of stability, rapid loss of nutrients, a decrease of Bonitet score, quality group, and acceleration of degradation process. Mainly, these soils are used as summer pastures, and hayfields, so it is necessary to obey grazing rules in order not to lose their structure. At the same time, it is important to decrease retail use from summer pastures to closed farms and apply in liberated territories.

The soils with the middle sensitiveness (43,5%) spread under the forest and in forest-free areas, one of the main conditions is to prevent deforestation and to follow agrotechnical rules when using these lands to prevent their degradation. Here grazing of the animals in the forest areas must be prevented, the tourism objects must be established in a specially planned way, and the ecotourism organization in the areas with sensitive forest trees must be paid attention to. The soils with less sensitiveness (20,8%) spread in the foothill zone. Though these soils are stable, the agrotechnical rules must be obeyed to keep their structure. So, this part of the research zone is used under the sowing and garden areas. Here the soils should be fertilized in time, and a special approach should be taken to prevent the spread of surface erosion in areas where irrigation is applied.

It is also important to take into account other criteria that analyze the rational use the soil like: soil cover, Bonitet score, humus (%), expanding height, the inclination of the zone, granulometric composition, and biomass productivity (Table 4). Table 5 shows the results of applying these criteria to the studied area.

Table 4. Criteria for assessing the importance of soil cover.

Importance	Bonitet score	Humus	Spreading height	The inclination of the zone	Granulometric composition	Biomass productivity
High	85-100	3.5-6.5	100-1200	1-20°	Heavy loamy	> 40 s/ha
Middle	60-85	2.0-3.5	100-1500	20-35°	Medium loamy	25-40 s/ha
Low	< 60	< 2.0	1500-2500	> 35°	Medium clayey	< 25 s/ha

Source. (Bruns, 2003; Turner, 2004).

Table 5. Investigation of soil cover of the mountain geosystems over importance criteria on the north-eastern slope in the Great Caucasus.

Soil types	Spreading height	Slope	Bonitet score	Humus	Granulometric composition	Erosion rate	Danger of erosion	Biomass productivity	Assimilation from zone
Mountain–meadow primitive	>3000	High (1,5-2,1)	89	2-3	-	Heavily, moderately eroded	Very dangerous	3,6-4,1	Less used
Mountain–meadow turf	2500-3000	High (1,2-2)	89	3,3-7,8	Light, average, and heavy loamy	Heavily and moderately eroded	Very dangerous	26,5-34,9	Summer pasture
Mountain – meadow - steppe	1800-2500	High (1-1,5)	72	2,57-5,63	Light and average loamy	Moderately eroded	Dangerous	3,1-3,7	Summer pasture, hayfield

Mountain-forest brown	900-1800	Average (0,6-0,9)	87	2,64-4,57	Light and average loamy	Weakly, moderately, and heavily eroded	Dangerous	27-28	Forest (beech, hornbeam)
Mountain–forest turf carbonate, typical	1000-1500	Average (0,4-0,6)	86	3,75-5,60	Average loamy	Moderately and heavily eroded	Average dangerous	20-23	Forest
Mountain-forest brown	600-1200	Average (0,5-0,7)	87	3,93-2,66	Light and average loamy	Moderately eroded (wind and water)	Average dangerous	11,6-22,7	Winter pasture (arable land)
Meadow-brown	200-600	Low (0,2-0,4)	85	3,05-3,93	Loamy and clay	Weakly eroded	Light dangerous	6,3-7,2	Winter pasture (perennial arable area)
Mountain-gray-brown	200-500	Low (0,5-0,3)	65	2,01-3,78	Light, average, and heavy loamy	Weakly eroded	Light dangerous	6,6-7,5	Winter pasture (arable area)
Flood-lands alluvial-meadow	River valleys	Low (0,3-0,02)	63	1,8	Heavy loamy	Not eroded	Not eroded	-	-
Rocky outcrops	2000-3000	High (2-3,4)	-	-	-	Heavily eroded	Very dangerous	-	-

In the research zone 1011,8 km² (28%) of soils are high, 2195,3 km² (45%) are middle, and 1356,8 km² (48%) are low soils. While compiling a significance map it was defined that the high-importance lands spread in areas up to 200-500 m above sea level, but the low-importance soils spread above 1800 m above sea level (Figure 2).

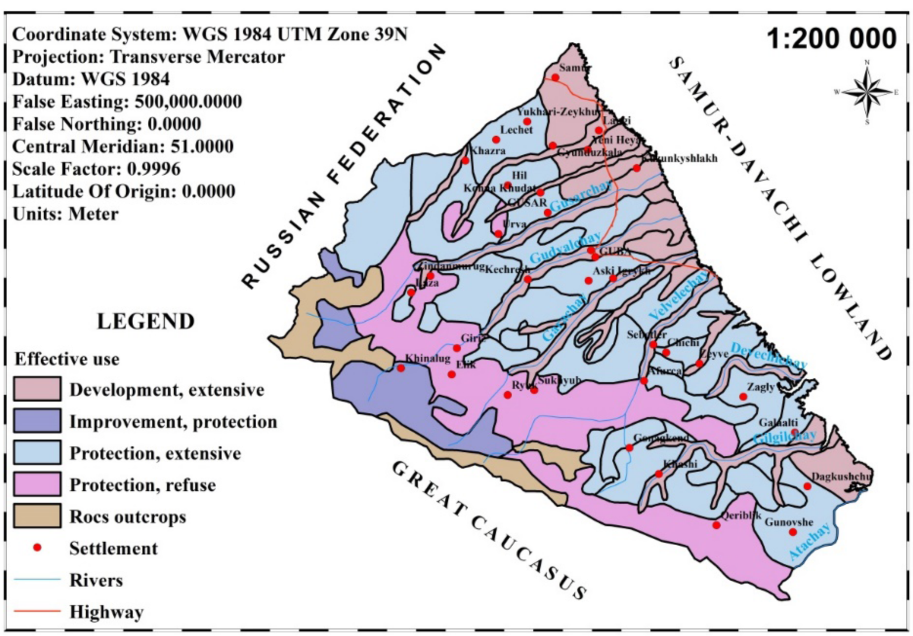

Figure 2. Rational use map for soil cover of the mountain geosystems on the northeastern slope of the Great Caucasus.

As can be seen from Figure 2 protective, extensive use surrounds 1011,8 km^2 of the research zone. The grazing should be prevented, their correct use should be provided in the soils spread at a height of 200-400 m and around the sea. Important measures to consider are: the transition to a terraced planting system on the slopes with higher inclination (25-30%) (in the zone where brown-mountain-forest soils spread), the cleaning of productive soils from stones, the prevention of over-irrigation of soils on the slopes with the higher inclination, as well as the expansion of sowing areas.

The purpose of the integration of the soils in the research zone was determined based on maps of importance and sensitiveness for soil cover use. Then, it should be noted that 3 main aims and directions must be pursued:

1. Protection – aims for the stability of the modern stave of the definite zones. In this situation, neither increase of the human's anthropogenic effects on the zone nor a sharp decrease isn't required.
2. Development – is a process directed to change of available state in space and time of the definite zone. The development process of the zone occurs in the form of active human intervention. As a rule, this process happens under the full control of man.
3. Improvement – is a measure that is realized to change the available situation for improvement.

Taking the above into account, next recommendations are provided to improve the soil use in the area. There is the development potential of the soils located 200-800 m above the sea which are good for development of crops. The sowing areas should be enlarged (garden areas should be expanded and increased productivity), for which they should be obeyed the norm in winter pastures, (1-4 cattle). Fruit-vegetable storage chambers near Samur checkpoint should be increased to improve the export of fruits and vegetables and be improved transport infrastructure.

The areas that refused protection and usage are soils spread under forest cover which encompass 1031 km^2. Their use leads to deforestation because they are under the forest. Therefore, we must refuse the use of these soils and protect them. Besides, regular monitoring should be performed to increase productivity and restoration of the forests in the same zones.

Protection of rare tree species should be controlled near the Tangalti and Kurkun settlements, so an area of the National part should be widened in the zones belonging to the forest, and the forest zone consisting of slip-resistant wood species should be constructed near the Urva, Atuj, and Firig villages.

The soils with the capacity of improvement surrounds the zones with the summer pastures higher than 1800 m above the sea, its total area is 295,1 km^2. These soils lost their quality because of intensive and irregular grazing, for which they dont protect of landslides, ravines and other negative processes. That's why these soils should be improved and protected. In the mentioned zones tourism especially village tourism should be developed. The measures against erosion, landslide, and stream must be realized, pastures, and hayfields should be strengthened ecologically. Finally in the soils which need to be protected, we have to prevent grazing on fertile lands and ensure to use of land properly. On high slopes (25-30°), it is advisable to switch to a terraced planting system.

CONCLUSIONS

Soil cover is the amount and type of vegetation or materials that cover the ground surface, and it is a key element of the terrestrial ecosystem having important effects on the environment and on people's quality of life. Proper ground cover has many benefits such as:

protects the soil: vegetation and other soil cover materials protect the soil surface from erosion and compaction, helping to maintain soil structure and fertility.

filters and retains water: ground cover acts as a natural sponge that traps rainwater and filters it into the ground, which can help prevent floods and droughts.

provides habitat: ground cover provides a home for a wide variety of plants and animals, which in turn contributes to biodiversity and ecosystem health.

absorbs and stores carbon: plants and other components of the ground cover absorb and store carbon, which can help mitigate climate change.

improves air quality: ground cover can help purify the air by absorbing and neutralizing pollutants and greenhouse gas emissions.

provides ecosystem services: soil cover provides ecosystem services such as pollination, water purification, and flood protection.

In short, soil cover is essential for the health of the ecosystem and for people's quality of life, so it is important to maintain and protect it to ensure that it continues to provide these benefits in the long term.

As it could be seen in the investigation, in the Azerbaijani territory there is a great variety of soils, so for its proper use, different strategies must be followed. In the article, potential actions to be followed for this purpose were analyzed, although it is recognized that in its implementation there are various difficulties of multiple dimensions. However, despite this, it is important to take actions because, as has been mentioned before, the ecosystem services provided by the soil are essential to maintain an adequate quality of life for people and the environment.

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