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გარემოს დაცვისა და სოფლის მეურნეობის სამინისტრო

Food and Agriculture Organization of the United Nations

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SUSTAINABLE PASTURELAND MANAGEMENT

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The opinions expressed in this material are those of the author and do not reflect the views of the project team members or the Global Environment Facility (GEF).

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INTRODUCTION

In Georgia, natural pasturelands occupy about 23% of the country's territory, and their wise management is crucial for the development of agriculture[1].

Disruption of the rotational grazing system and unregulated use of pasturelands have further aggravated the degradation process, leading to a reduction in their productivity by nearly half and necessitating restoration and improvement measures[1]. The degradation of pastures is accelerated by ongoing climate change; the increase in temperature and the occurrence of droughts significantly affect the species composition of the vegetation and cause the early termination of their growth.

To stop the degradation of pastures and other natural ecosystems and promote their restoration and improvement worldwide, the United Nations General Assembly proclaimed the period from 2021 to 2030 as the United Nations Decade on Ecosystem Restoration under Resolution 73/284[2], on March 1, 2019. The primary aim of the document is to prevent, halt, and reverse negative processes and restore damaged ecosystems worldwide.

In accordance with the five voluntary targets of the Land Degradation Neutrality (LDN), Georgia, considering its national sustainable development goals[3], has set the objective of maintaining healthy and productive land resources and increasing their area.

LDN is the concept of maintaining a neutral balance of land degradation. It was developed under the United Nations Convention to Combat Desertification (UNCCD) and later reflected in the United Nations Sustainable Development Goal 15: Life on Land.

The primary goal of LDN is to maintain and/or increase the area of healthy and productive lands.

To achieve the targets set within the framework of LDN, a project titled „Achieving Land Degradation Neutrality Targets of Georgia through Restoration and Sustainable Management of Degraded Pasturelands (GCP/GEO/006/GFF)[4]," initiated by the Ministry of Environmental Protection and Agriculture and funded by the Global Environmental

1 Rural Development Strategy of Georgia, 2017-2020.

2 United Nations Decade on Ecosystem Restoration (2021-2030): resolution / adopted by the General Assembly. 2019

3 Resolution of the Government N°2328, November 12, 2019, Tbilisi. National Document of Sustainable Development Goals

4 Achieving Land Degradation Neutrality Targets of Georgia through Restoration and Sustainable Management of Degraded Pasturelands | GEF (thegef.org)

Fund (GEF), is being implemented in Georgia. The project aims to achieve the following national targets:

Target 1: Integration of LDN principles into national policies, strategies and planning documents;

Target 4: Rehabilitation of degraded lands.

The project considers restoration of 530 ha of pasturelands in three target municipalities: Kazbegi, Gurjaani and Dmanisi. Within the framework of the project, the current condition of pastures was assessed, and pasture management plans were developed for selected pilot areas in each municipality.

This document contains a review of key sustainable pasture management measures, alongside with their advantages and disadvantages. It also provides examples of the measures and methods developed within the project to halt degradation and restore degraded areas in the pilot pastures.

Sustainable pasture management is crucial for ensuring the health of pastures, which provide important ecosystem services such as water and climate regulation, reduction of soil erosion, preservation of biodiversity, and the production of plant, meat, and dairy products[5].

Sustainable pasture management faces a number of challenges, including:

- Excessive unsystematic grazing, burning and growth of unwanted plants (weeds);
- Insufficient soil organic carbon content;
- Soil degradation: erosion, compaction, crusting.

Therefore, it is crucial to introduce sustainable land management practices that will help:

- Enhance food security;
- Halt soil degradation;
- Increase soil moisture;
- Increase pasture fertility (primary production) and enhance nutrient cycling;
- Conserve biodiversity (species and landscape diversity);
- Restore carbon stocks in soil and vegetation cover;
- Reduce CO2 in the atmosphere and abate global warming.

5 Bengtsson, J.; Bullock, J. M.; Egoh, B.; Everson, C.; Everson, T.; O'Connor, T.; O'Farrell, P. J.; Smith, H. G.; Lindborg, R. Grasslands-More Important for Ecosystem Services than You Might Think. Ecosphere 2019, 10 (2), e02582. https://doi.org/10.1002/ecs2.2582.

1. IMPACT OF UNSYSTEMATIC GRAZING ON PASTURELANDS

1.1 Impact of unsystematic grazing on pastureland productivity, vegetation and its species composition

Pasturelands are natural ecosystems that are resilient to the effects of changing environmental factors, including grazing. Unsystematic grazing can lead to ecosystem degradation, habitat loss and fragmentation[6]. Any type of grazing affects the vegetation of pasturelands, either directly or indirectly, depending on factors such as timing, intensity, and frequency of grazing. In general, the more diverse the species composition of the vegetation, the more resilient the pastureland is to the effects of grazing.

The herbaceous plants growing on pasturelands provide herbivorous cattle with nutrients such as proteins and carbohydrates. These nutrients, essentially plant food, are produced through photosynthesis, primarily occurring in green plant tissues, particularly in leaves. During grazing, the loss of leaves and other green parts temporarily reduces the production of these substances in plant organs.

Like all other living things, plants also need food for survival and growth. The food that plants produce through photosynthesis supports their basic functions, such as dormancy, the formation of new roots and leaves in the spring, and the restoration of leaves/stems lost due to grazing or trampling.

Unsystematic grazing can lead to the excessive use of plants. As illustrated in the graphic image below (Pic. 1), when a significant portion of the above-ground biomass is grazed, the growth of plant root systems is either partially delayed or completely halted. Research has shown that when the above-ground green mass is reduced by 50%, the plant root system continues to grow and develop normally; when 70% of the green mass is reduced, 50% of the roots slow down their growth for 17 days, while when 90% of the green mass is lost, root growth stops entirely for 17 days[7].

As a result:

1) The accumulation of organic carbon in the soil decreases as reserves of organic compounds in the roots are used to restore the above-ground parts of plants. Consequently, a significant part of the root system is lost;

6 Cravino, A.; Perelló, A.; Brazeiro, A. Livestock–Wildlife Interactions: Key Aspects for Reconnecting Animal Production and Wildlife Conservation. Animal Frontiers 2024, 14 (1), 13–19. https://doi.org/10.1093/af/vfad069

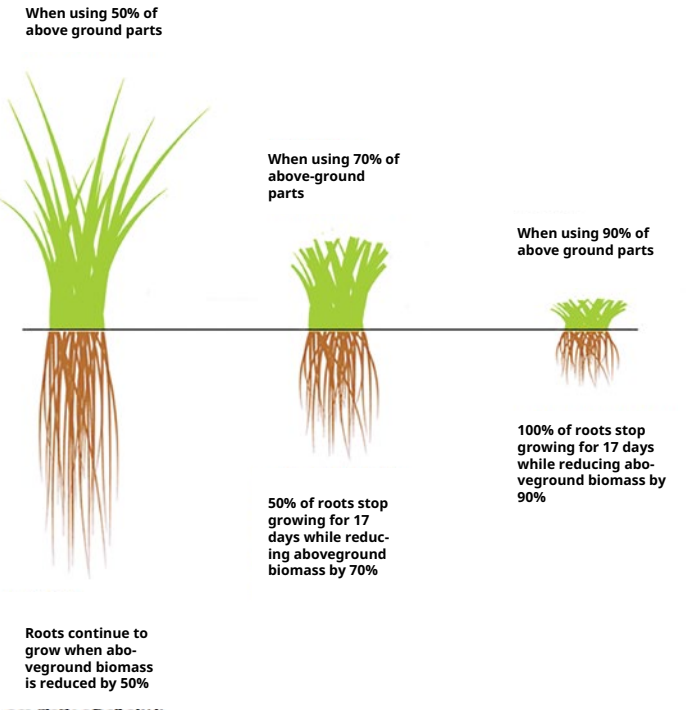
7 Great "Grass Farmers" Grow Roots | On Pasture

2) Resilience to drought decreases, especially due to the loss of a significant part of the roots in the deep layers of the soil;

3) The death of the plant can be expected in the case of severe decline due to continuous or multiple grazing;

4) Erosion is developed;

5) The water retaining capacity of the soil decreases due to the reduction of the humus (fertile) layer of the soil[8].



Pic. 1. Effects of overgrazing on plant root growth

Unsystematic grazing affects the sustainability of pastureland resources; however, with proper management, grazing can provide ecological benefits compared to zero grazing. A study conducted in the USA showed that in arid and semi-arid regions, up to a 40% grazing load can have a more positive effect on valuable forage plants than zero grazing[9].

8 Robert K. Lyons and C. Wayne Hanselka. Grazing and Browsing: How Plants are Affected. The Texas A&M University System

9 Holechek, J. L.; Baker, T. T.; Boren, J. C.; Galt, D. Grazing Impacts on Rangeland Vegetation: What We Have Learned. Rangelands 2006, 28 (1), 7–13. https://doi.org/10.2111/1551-501x(2006)28.1[7:giorvw]2.0.co;2.

Rotational grazing leads to improved characteristics of vegetation and soil cover. Studies in various countries have shown a yield increase of 0.41 t/ha compared to reference conditions, grass nutritive value rises, while soil phosphorus levels increase, soil density decreases to 1.24 g/cm3, compared to 1.38 g/cm3 under uncontrolled grazing.

1.2 Impact of unsystematic grazing on soils

Compared to other pilot plots[10], overgrazed pastures are characterized by significantly lower yields, reduced vegetation coverage (45%), and deteriorated indicators of species composition and grass height.

Animals have a significant impact on pastureland soils, varying according to the weight of the animal, size of the hooves, and species and age of the animal. Cattle exert substantial pressure on the soil, particularly noticeable in high soil moisture conditions. According to studies, pastures intended for cattle have 57-83% lower porosity and 8-17% higher density compared to reference pastures[11].

Livestock grazing also significantly impacts the chemical composition and fertility of soils. Cattle, especially dairy cows, produce substantial amounts of organic waste in the form of dry and liquid excrements. On average, each adult cow produces approximately 20 tons of excrements annually (dry and liquid), with roughly 50% remaining on pasture[12].

Significant amounts of nutrients, averaging within the following limits: nitrogen 40-60 g/m2, phosphorus 14-20 g/m2, potassium 16-25 g/m2, calcium 40-60 g/m2, and magnesium 10-14 g/m2, are returned to pasture soils from cattle manure. Therefore, manure has a considerable effect on the chemical composition of pasture soils and is thus a potential source of nutrients for plants. Additionally, urine serves as another nutrient source, particularly nitrogen. Nitrogen primarily occurs as hydrolyzed urea and, once in the soil, becomes readily available to plants. By enhancing nitrogen nutrition, biomass yield increases.

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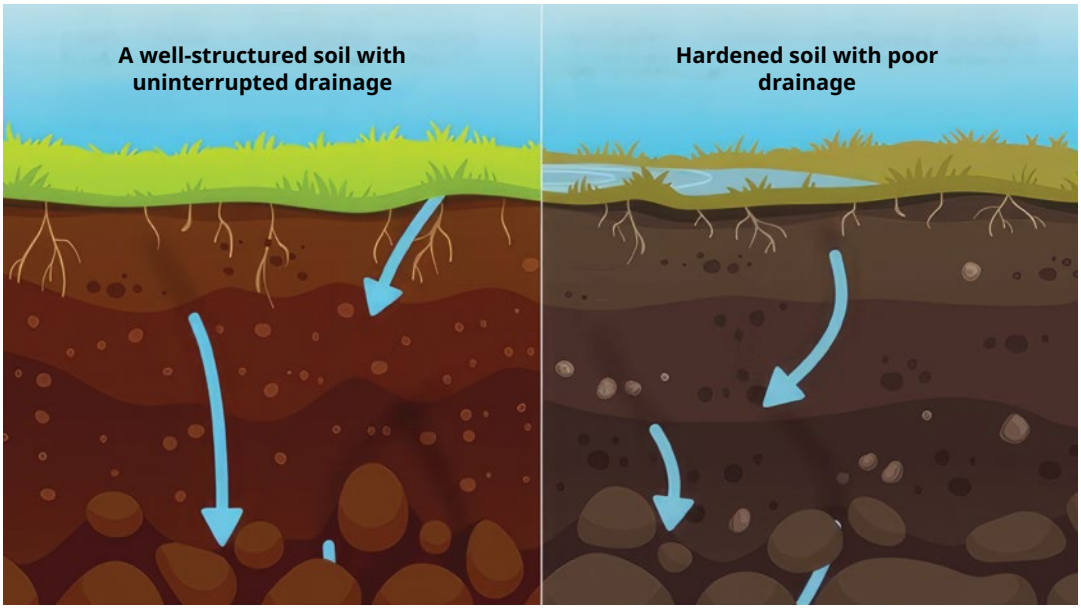
10 Nasiyev, B., Shibaikin, V., Bekkaliyev, A., Zhanatalapov, N. Z., & Bekkaliyeva, A. (2022). Changes in the quality of vegetation cover and soil of pastures in semi-deserts of West Kazakhstan, depending on the grazing methods. Journal of Ecological Engineering, 23(10).

11 Kurz, I., O'Reilly, C., Tunney, H., Bourke, D., The impact of grazing cattle on soil physical properties and nutrient concentrations in overland flow from pasture, Part B, 5022b, Teagasc, 2007.

12 Bilotta, G. S.; Brazier, R. E.; Haygarth, P. M. The Impacts of Grazing Animals on the Quality of Soils, Vegetation, and Surface Waters in Intensively Managed Grasslands. Advances in Agronomy 2007, 4, 237–280. https://doi.org/10.1016/s0065-2113(06)94006-1.

Soils with a high sodium content in arid regions often exhibit the formation of a surface crust (Pic. 2), which is exacerbated by the degradation of vegetation cover. This hardened surface layer or crust restricts water penetration into the soil and inhibits plant germination, thereby impeding pasture recovery (Pic. 3).

Pic. 2. Crust formed on soil surface



Pic. 3. Water conductivity in soils with good (a) and poor (b) structure

According to studies, intensive grazing deteriorates the qualitative properties of soil: a decrease in the content of organic carbon, humus, and phosphorus was observed, and soil compaction increased to 1.38 g/cm3. Additionally, soil structure deteriorated, and alkalinity increased.

1.3 Impact of unsystematic grazing on livestock health and productivity

Animal health is an essential component of a healthy grazing system. Healthy animals achieve high productivity and reduce costs for veterinary services and medications. Proper grazing management, which includes providing low-cost feed, access to clean air and water, and ensuring physical movement on the pasture, enhances animal health and maintains natural environmental conditions for them.

Proper management of pastures significantly reduces the spread of parasites and diseases, helping to prevent livestock morbidity. Conversely, unsystematic grazing can be harmful to animals, as it creates favorable conditions for the spread of parasites. Most worm larvae are found in grass at a height of 2 cm from the soil surface. Therefore, animals that graze on quality pastures and avoid grazing too close to the surface are better protected from being affected by parasites

For example, the spread of the liver fluke (Fasciola hepatica), also known as the sheep liver fluke, which causes animal fasciolosis, can be reduced by preventing livestock from grazing in waterlogged areas. These areas often form due to soil hardening or surface crust formation, which is characteristic of pastures subjected to unsystematic or overgrazing conditions. Such waterlogged areas are potential breeding grounds for snails, which serve as intermediate hosts for the liver fluke.

Like parasites, infectious diseases also spread easily under unsystematic grazing. Overgrazing creates two problems that can have a cumulative effect: first, due to the lack of forage on overgrazed pastures, animals experience nutritional stress, which weakens their immune systems and defensive capacity. Additionally, due to low grasses, they are forced to graze on plant parts close to the soil surface, increasing their contact with and likelihood of infestation by parasitic organisms. Therefore, it is important to avoid overgrazing to maintain both pasture productivity and animal health.

Under unsystematic grazing, weeds easily spread on the pasture, often including poisonous and harmful plants that can have damaging, and sometimes fatal, effects on animal health. The increase in the consumption of harmful and poisonous plants is driven by the lack of forage grass on the pasture, which adversely affects the health and productivity of livestock, especially in conditions of food scarcity.

2. A BRIEF OVERVIEW OF THE ESSENCE AND EXISTING MODELS OF PASTURE MANAGEMENT

Effective management of pastures determines the health and sustainability of ecosystems. Well-managed pastures are essential for the development of animal farming and maintaining pasture productivity. One of the best ways to restore degraded pastures is through improved pasture management[13].

Benefits include weed reduction, improved soil drainage, enhanced groundwater and surface water quality, efficient nutrient allocation, and reduced reliance on supplemental feeding.

Successful pasture management involves careful planning, regular monitoring and timely interventions to maintain optimal conditions and promote sustainable livestock production.

This process involves several practices aimed at enhancing pasture yield, health, and sustainability. The main models of pasture management include:

Continuous grazing under predetermined pasture load, where one pasture is used throughout the season. The primary advantage of this model lies in its easy management and low costs.

However, continuous grazing can result in uneven pasture utilization and overgrazing (Pic. 4).

Pic. 4. Under continuous grazing, cattle roam freely across the pastureland, resulting in uneven loading of the grazing area.

Rotational grazing involves utilizing several paddocks for livestock grazing. In this practice, animals are rotated between different paddocks to allow grass to recover and prevent overgrazing.

13 Papanastasis, V. P. Restoration of Degraded Grazing Lands through Grazing Management: Can It Work? Restoration Ecology 2009, 17 (4), 441–445. https://doi.org/10.1111/j.1526-100x.2009.00567.x

Rotational grazing promotes better feed utilization and healthier use of pastures (Pic. 5).

Pic. 5. Under simple rotational grazing, animals are alternately grazed on several paddocks to facilitate grass recovery.

Intensive rotational grazing involves dividing a field into numerous smaller units, which cattle continuously move between. This method enables more precise control of pasture loading and grass renewal.

This approach maximizes feed utilization and ensures the health of the pasture (Pic. 6).

Pic. 6. Under intensive rotational grazing, animals are grazed alternately on many small paddocks, enhancing the efficiency of pasture utilization.

2.1 An overview of the advantages and disadvantages of the discussed pasture management models, considering both local and international experiences

Continuous grazing under predetermined pasture load:

Advantages:

- Simplicity of management;
- Low capital costs;
- May work successfully in some cases if annual targets for pasture condition are met.

Disadvantages:

- Low yield and underutilization of pasture due to extensive trampling of grass.
- Decreased height and quality of herbage;
- Uneven distribution of manure of pasturelands;
- Potential for spread of weeds;
- Potential for spread of parasites and diseases.

Rotational grazing:

Advantages:

- Higher yield compared to continuous grazing;
- Enables pastures to rest and restore herbage;
- Potential to extend the grazing season;
- More even distribution of manure on the pasture;
- Potential to obtain biomass for hay, haylage or silage production from surplus herbage.

Disadvantages:

- Requires additional fencing and watering points;
- Herbage restoration and use are not optimal if grazing lasts more than 3 days. After 3 days livestock begin to consume newly grown grass.

Intensive rotational grazing:

Advantages:

- Highest yield and full utilization of pasture;
- Potential to obtain the highest quality forage with a metabolizable energy[14]

14 Metabolizable (transformable) energy is the energy obtained from food that is available for maintaining the growth and productivity of the animal. It is measured in megajoules per kilogram of dry matter (MJ/kg).

of 11-12 MJ/kg;
- Potential for grazing more livestock per unit area;
- Even distribution of manure on the pasture;
- Weed control through grazing;
- Reduced demand on supplemental feeding due to an extended grazing season;
- Potential to obtain biomass for hay, haylage or silage production from surplus herbage;
- Limited spread of parasites and diseases.

Disadvantages:

- Requires additional management measures, such as herbage monitoring and estimating forage quantity;
- Incurs additional costs for infrastructure setup, including fences, watering points, and sheds.

2.2 Methodology for establishing a rotational grazing scheme

2.2.1 Assessment of grazing resources and determination of pasture yield

To accurately assess pasture yield, the amount of obtained biomass should be converted to dry matter. This value will help determine the pasture's potential and inform pasture management decisions, such as assessing forage resources and determining the need for or cost of fertilizers, etc. Yields of natural pastures are seldom assessed, unlike agricultural crops grown on arable lands, due to the complexity and labor-intensive nature of the assessment process. Several methods of pasture yield assessment exist that do not require grass collection. They can be categorized into direct and indirect methods. Direct methods involve estimating yield from grass samples collected in the pasture, while indirect methods rely on one or more plant characteristics to estimate yield. The ruler method is among the most commonly used methods. However, it requires calibration for a specific pasture to ensure accuracy, which can be a labor-intensive process despite its simplicity.

2.2.1.1. Direct method – manual mowing

This method involves mowing sample areas, then drying and weighing the obtained biomass. Its accuracy heavily relies on pasture variability and sampling efficiency. While manual mowing is accurate, it is labor-intensive, making it impractical for frequent use

2.2.1.2. Indirect method – ruler method

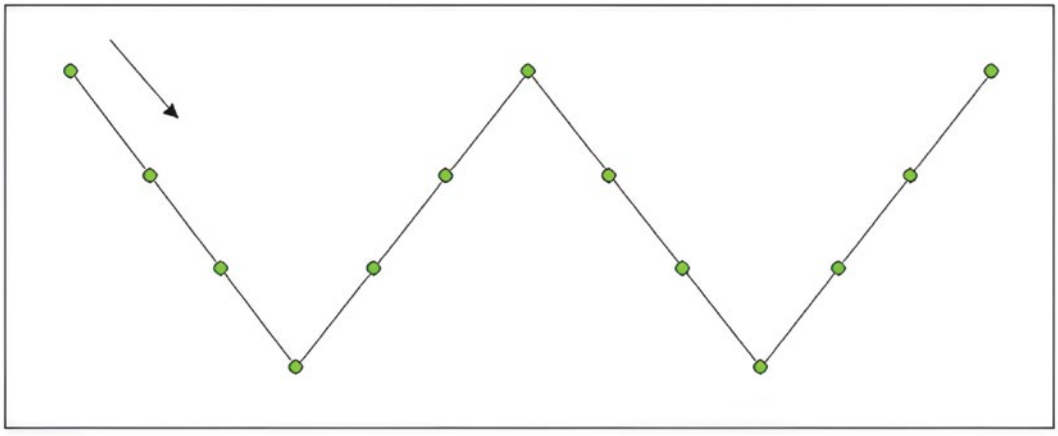
The main principle of this method is to relate plant height to pasture yield. For more accuracy, a disk ruler (Pic. 7) is used to measure the average height of the herbage, however, a regular ruler can also be used (Pic. 8).

Walk through the pasture in a random zig-zag pattern, recording the plant height at every 7-8 meter interval[15] (Pic. 9). In natural pastures with non-uniform vegetation development, it is important to take measurements for each distinct section that best represents the characteristics of that area.

Pic. 7. Measuring plant height using a disk ruler

15 Determining Pasture Yield. Penn State Extension. https://extension.psu.edu/determining-pasture-yield.

Pic. 8. Measuring plant height using a ruler



Pic. 9. A trajectory of movement through the pasture in a zig-zag pattern, indicating plant height measurement points

After collecting the data, calculate the average height of the herbage by dividing the sum of all heights by the number of measurements. For example, if the average height of the grass is 20 cm and the literature suggests that the accumulation of dry matter per centimeter of plant height is on average 25 kg, then to calculate the dry matter per hectare, multiply the average height of the grass (20 cm) by the accumulation rate of

dry matter (25 kg). Consequently, the weight of dry matter per hectare is 500 kg (20 x 25 = 500).

The ruler method is quicker, simper, and cheaper, but is not as accurate as the direct measurement method described above.

2.2.1.3. Calibration of the ruler method

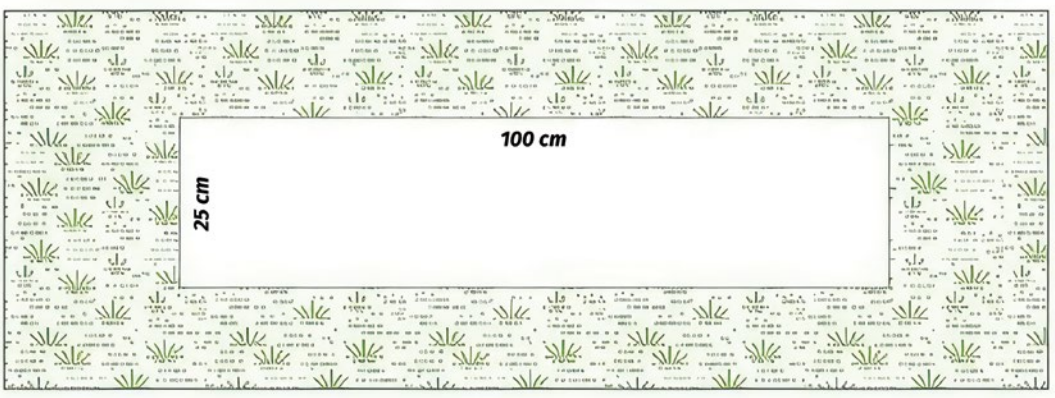
Required tools:

- Sickle or electric mower
- Disc or regular ruler (up to 1 m long)
- Tape measure (to measure distance)
- Fabric sack
- Scales

Steps

- When moving through the pasture in a zigzag pattern (Pic. 9), measure and record the height of the grass every 7-8 meters. For example, if the values obtained from measurements in 10 places are 14, 17, 15, 16, 13, 18, 11, 10, 21, and 15 cm, the average height will be their sum divided by the number of measurements: (14+17+15+16+13+18+11+10+21+15)/10 = 15 cm;

- At the measurement points (in this case, 10 points), cut the grass close to the ground along 1 meter, following the cutting width of the sickle or electric mower (Pic. 10), record the cutting width, e.g. 25 cm;



Pic. 10. A mowed strip that is 1 meter long and 25 centimeters wide

- Put cut grass into the sack;
- Repeat the procedure until the end of the zigzag path. On relatively uniform pastures, measuring and sampling at 10 points is sufficient;
- After taking the samples, weigh the collected fresh grass. In this case the weight is 2.5 kg;
- Take an average sample of 0.5 kg from the collected grass and dry it in a microwave oven until it reaches a constant weight.

Note: The drying time in the microwave oven depends on the water content of the grass, and about 3-5 minutes is usually sufficient. The final weight obtained after drying is the dry mass of the sample without water, known as the dry matter, containing both organic and inorganic substances.

- Divide the obtained dry weight by the initial fresh weight, i.e., calculate the percentage of dry matter (DM) is using the following formula:

$$\text{DM (\%)} = \frac{Dry\ weight\ (kg)}{Fresh\ weight\ (kg) \times 100}$$

i.e., percentage of dry matter (%) = 0.05 / 0.5 X 100 = 10%

- Determine the total amount of dry matter in mowed grass based on the obtained percentage using the following formula:

$$\text{Total DM (kg)} = \frac{Total\ fresh\ weight\ (kg)\ X\ Dry\ matter\ (\%)}{100}$$

i.e., total dry matter = 2.5 X 10 / 100 = 0.25 kg

- The area of the paddock where the grass was cut is determined by the formula:

$$\text{Area of the paddock } (ha) = \frac{\begin{matrix}Length\ of\ the\ strip\ (m) \times \\ Width\ of\ the\ strip\ (m) \times\ number\ of\ samples\end{matrix}}{10000}$$

i.e., area of the paddock (ha) = 1 X 0.25 X 10 / 10,000 = 0.00025 ha

- Calculate dry matter (DM) in kg per hectare using the following formula:

$$\text{DM per hectare } (kg) = \frac{Total\ dry\ matter\ (kg)}{Area\ of\ mowed\ strip\ (ha)}$$

i.e., dry matter per hectare (kg) = 0.25 / 0.0005= 500 kg

- Calculate the sum of heights of measured grass (SHM) using the following formula:

Sum of measured heights (cm) = sum of heights of all measured grass

- In this case

SHM (cm)=14+17+15+16+13+18+11+10+21+15=150 cm

- Calculate average height of herbage (AHH) using the formula:

$$\text{AHH (cm)} = \frac{Sum\ of\ heights\ of\ measured\ grass\ (cm)}{Number\ of\ samples\ (units)}$$

i.e., the average height of herbage (cm) = 150 / 10 = 15 cm

- Calculate average weight of dry matter (AW) per 1 cm of plant height (PH) using the formula:

$$\text{AW of DM per 1 cm of PH } (kg/cm) = \frac{Dry\ matter\ per\ hectare\ (kg)}{Pasture\ yield}$$

i.e., average weight of dry matter per 1 cm of plant height (kg/cm) = 500 / 15 ≈ 33.33 kg/cm.

2.2.2. Determining the area of a paddock for rotational grazing, considering the weight and number of livestock

The time required for herbage restoration on a pasture depends on the plant species composition, soil fertility, water availability, and season.

In the spring, about 21 days are needed for pasture herbage restoration, while from the second half of summer, this period can extend to 42 days. Therefore, the number of paddocks required for rotational grazing depends on the number of grazing days and the maximum rest period for each paddock. The rest (restoration) periods should be based on the herbage renewal rate, which varies with the season and weather conditions.

According to studies, short grazing with high loads of no more than 1 day (usually 12 hours) is the preferred option, although an average load of 5-6 days is recommended for pilot areas. To determine the paddock area, data on pasture yield and the total weight of the grazing livestock are required. In the example mentioned above the yield of study pasture in terms of dry matter is 500 kg/ha. The area to be allocated for a rotational grazing system designed for 50 heads of livestock (total weight 20,000 kg, with each weighing an average of 400 kg) on the mentioned pasture is calculated by the ratio of the dry mass of herbage required for the herd (2.5% of the total mass) to the dry mass of herbage available on the pasture:

$$Paddock\ area = \frac{Daily\ herbage\ intake}{Pasture\ yield} = \frac{20000 * 2{,}5\%}{500} = \frac{500}{500} = 1.0\ ha$$

Therefore, the area required for one-day grazing in this case is 1.0 ha. Considering the pasture condition, grazing can be planned with a 2-day delay to reduce the number of required paddocks. As a result, the area of each paddock will increase to 2 ha, ensuring full use of the pasture and reducing selective grazing.

Then, the paddock rest period and the number of paddocks are determined based on the maximum time required for herbage to recover. For example, if the maximum recovery time for the pasture is 34 days, then the number of paddocks for a 50-head herd with a total mass of 20,000 kg, requiring a daily paddock area of 2.0 ha, is calculated as follows:

$$Number\ of\ paddocks = \frac{Number\ of\ paddock\ rest\ days}{Number\ of\ grazing\ days} + 1 = \frac{34}{2} + 1 = 17 + 1 = 18$$

According to the calculation, a 50-head herd weighing 20,000 kg will require 18*2=36 ha of pasture, divided into 2 ha paddocks. The herd will stay on each 2 ha paddock for 2 days before moving to the next paddock in rotation. This means the herd will return to the first paddock after 34 days, allowing time for herbage recovery.

2.2.3. Periodic monitoring of rotational grazing system

When implementing a monitoring program, it is recommended to use data collection worksheets. Samples of these worksheets are presented in Annexes 1, 2, 3, and 4. These worksheets are necessary for conducting annual field monitoring, evaluation, and planning actions for the following year. The information provided in the first Annex is crucial for conducting pasture yield monitoring at the end of each year. It helps obtain annual data on the number of grazing days, weather conditions, and livestock quantity.

Preferably, field monitoring should be carried out at the beginning of fall using LADA and PRAGA field methodologies, with the field checklists provided in Annexes 1 and 2. Monitoring sites should be selected in advance in each paddock of the pasture.

Based on the field survey results, pasture users determine grazing goals and develop an annual action plan (Annex IV) for the pasture management unit. The final versions of both documents, in printed and electronic formats, are kept by the pasture users to assess the effectiveness of the current pasture management model in subsequent years.

3. THE ROLE OF PASTURE IMPROVEMENT MEASURES IN MITIGATING THE ADVERSE IMPACTS OF CLIMATE CHANGE

Agriculture contributes 20% of Georgia's total greenhouse gas emissions[16]. According to the Georgia's Nationally Determined Contribution document submitted under the Paris Agreement, Georgia is fully committed to an unconditional limiting target of 35 % below 1990 level of its domestic total greenhouse gas emissions by 2030, and to a target of 50-57% in case of the international support[17].

Rotational grazing is one of the sustainable agricultural practices that help farmers mitigate and adapt to climate change. Intensive rotational grazing systems can offer greater environmental and climate benefits but require effective management measures, constant monitoring, and higher initial costs compared to simple rotational grazing systems.

Greenhouse gas emissions cannot be completely eliminated from the livestock sector, but they can be reduced by introducing rotational grazing. Livestock, especially cattle, release methane during digestion, a process known as enteric fermentation. Methane released in this way accounts for 52% of the greenhouse gases from the agricultural sector, calculated as carbon dioxide equivalents[17]. Rotational grazing helps to reduce these emissions by providing higher quality forage, which is easier to digest and results in fewer emissions.

Studies indicate that methane emissions can be reduced by 22% through the introduction of rotational grazing and improvements in pasture management practices[18]. Additionally, the duration of the management systems' implementation plays a crucial role. Research conducted in the USA demonstrated that within the first two years of implementing rotational grazing, methane emissions decreased by 19% on participating farms. However, in farms where sustainable agricultural practices had been established for over 2 years, emissions decreased by 35%[19].

16 National Greenhouse Gas Inventory Report of Georgia: 1990-2017. Tbilisi, 2021

17 Georgia's Nationally Determined Contribution

18 DeRamus, H. A.; Clement, T. C.; Giampola, D. D.; Dickison, P. C. Methane Emissions of Beef Cattle on Forages. Journal of Environmental Quality 2003, 32 (1), 269–277. https://doi.org/10.2134/jeq2003.2690.

19 Rotational grazing mitigates greenhouse gas emissions (msu.edu)

4. EXAMPLES OF PASTURELAND RESTORATION ON PILOT PASTURES IN TARGET MUNICIPALITIES

Under the project „Achieving Land Degradation Neutrality Targets of Georgia through Restoration and Sustainable Management of Degraded Pasturelands" restoration plans have been developed for selected pilot pastures. These plans aim to achieve four main goals:

- To demonstrate that pastures and ecosystems can be restored in a relatively short period of time, specifically within 3 years (2022-2024). „Restoration" in this context involves reestablishing the ecosystem's functional processes (water cycle, nutrient cycle, vegetation dynamics, and energy flow) and approximating optimal land potential. The condition of the restored pasture should be assessed according to the UNCCD guidance on using the three indicators for achieving SDG 15.3 (land cover, land productivity, and soil organic carbon) (Sims et al., 2017), along with recommendations for using local indicators of land degradation (Orr & Crowe, 2017).

- To demonstrate that ecosystems and pasturelands can be restored under the current conditions of local communities and livestock populations using a management and planning tool. This means that extreme changes to existing socio-economic models and local livelihoods are not necessary; however, it is essential to motivate farmers to participate in joint data recording and planning.

- To demonstrate that restoration methods/techniques, along with investments available to farmers, can ensure profitability while increasing product quality and producers' income.

- To inform authorities and farmers about economic opportunities and proven tools and approaches, ensuring their widespread use at the local level and consideration in the development of municipal pasture management plans.

4.1 Pilot pastures in Naniani village of Gurjaani municipality

4.1.1 The condition of pilot pastures before improvements

For the project's purpose, two pilot pastures were chosen in Naniani village (see Map 1). The first pasture (Site A) is situated adjacent to Naniani village (see Map 2), covering an area of 25 ha and primarily utilized as grazing land for dairy cattle. The second pasture (Site B) is located farther from Naniani village, south of the S5 highway, near the Mkrali Ole river, covering an area of 35 ha.

Map 1. Location of the pilot pastures chosen in Naniani village

Map 2. Pilot pasture located adjacent to Naniani village

The condition of the first site of the Naniani pilot pasture (Map 2) illustrates how inadequate grazing (i.e. incomplete utilization of the grass cover's annual growth) can result in low-quality pasture with large amounts of biomass of low nutritional value (Pic. 11).

Pic. 11. Pilot pasture located adjacent to Naniani village, 2019

Due to the low grazing pressure, undesirable species, such as the sedge (Paliurus spina-christi), a thorny, and highly-branched shrub reaching up to 3 meters in height, have proliferated extensively in some areas (Pic. 12). This species inhibits the growth of other plants and complicates, and sometimes makes impossible, cattle movement on the pasture.

Pic. 12. Pasture with proliferated Paliurus spina-christi, 2019

On the second site (Map 3) of the pilot pasture in Naniani village of Gurjaani municipality, high-nutritive forage grasses have been diminished, and the proliferation of noxious and unwanted weed species has occurred due to overgrazing. In the least grazed areas, sea holly (Eryngium spp.) and licorice (Glycyrrhiza glabra) are widespread, leading to low pasture yields. Soil degradation on the pasture is evidenced by salinization (excessive soluble salts content) and alkalinity (increased exchangeable sodium content), affecting soil structure by increasing hardness and reducing water and air permeability. This, in turn, limits plant root growth and development, as well as the availability of water and air. Consequently, changes occur in the species composition of the vegetation cover, drought resilience increases, and recovery time lengthens.

Considering the pasture's condition from 2019 to 2021, both sites of the pilot pasture were utilized inefficiently, taking into account factors such as their location, biophysical properties, climatic conditions, and the discrepancy in grazing intensity, with one site being undergrazed while the other was overgrazed.

During this period, the first site of the pilot pasture was utilized by approximately 50 heads of cattle throughout the year, without the application of a season-based

management system. When the neighboring village also utilizes this pasture, the number of cattle on the pasture increases.

200 heads of cattle, 500 heads of sheep, along with a small number of goats and horses, were grazing on the second site of the pilot pasture. The pilot pasture was continuously utilized throughout the year.

4.1.2 Improvement measures implemented on the pilot pasture

Installing watering point

Watering points were installed at the livestock collection point in the village (Pic. 13), from where the herd is driven to the pasture daily. As a result, the village livestock can access water early in the morning, during rest in the afternoon, and in the evening when returning from the pasture to the village.

Before the implementation of the project, the village's livestock could only drink water twice a day from a spring located in the middle of the village.

Pic. 13. Installing watering point in Naniani village

Locating salt blocks on the pasture

Salt blocks (Pic. 14) were located on the pilot pastures of Naniani village. Salt blocks provide livestock with essential minerals, enhancing their productivity on low-quality pastures. Additionally, the salt blocks were placed to promote even pasture utilization. They were securely fixed with appropriate clamps to prevent movement downslope.

Pic. 14. Locating salt blocks on the pasture of Naniani village

Covering salinized pasture with hay

Two hectares of degraded and salinized areas within the second site of the Naniani pilot pasture were covered with hay - plant biomass (Pic. 15). The purpose of this measure was to disperse the seeds of local grass species. Mineral/salt blocks were also placed in these areas to attract cattle, which helped increase soil fertility through their excrements.

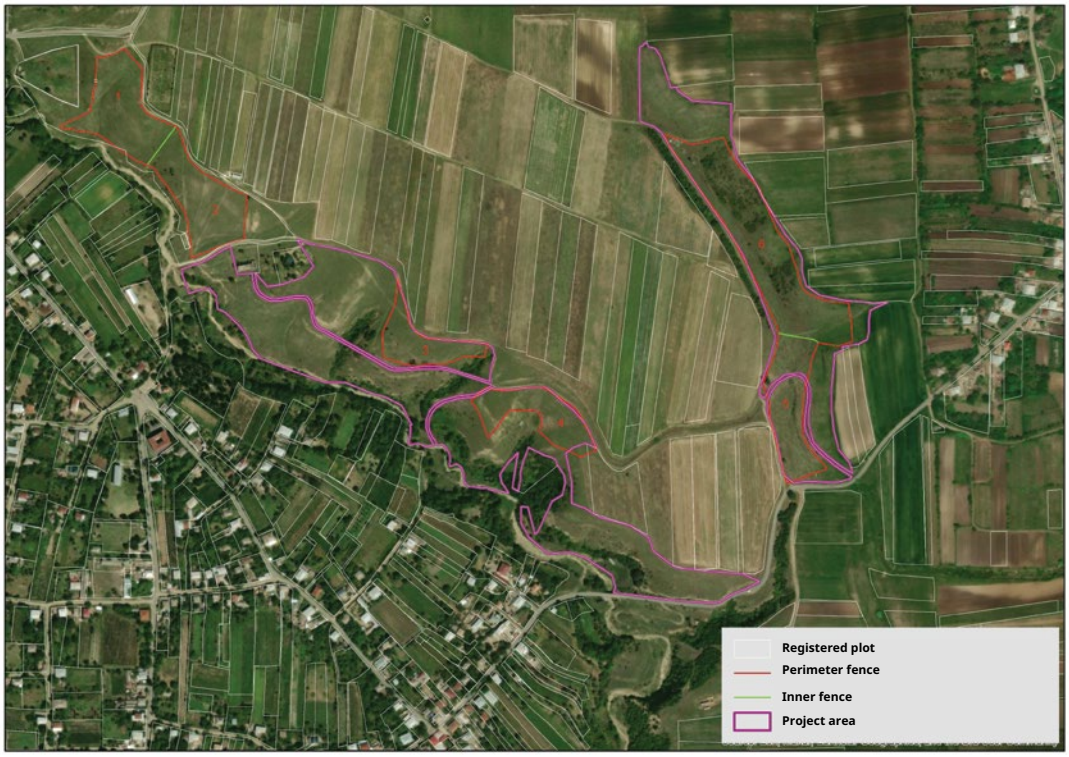
Pic. 15. Creating a temporary cover with hay on the Naniani pasture

Weed control

Due to the proliferation of weeds on the Naniani pasture, grass was mowed on the pilot pasture to a maximum height of 20-30 cm. This measure was taken to prevent the further spread of weed species, based on assessments and recommendations from the project's international and national experts. The grass was cut during flowering to prevent seed production. This measure was important for the further propagation and strengthening of grain and leguminous species, which are valuable forage species on the pasture.

Installing electric fencing

To organize rotational grazing, both sites of the pasture were divided into paddocks (Map 3 and Map 4). Electric fencing was installed around each paddock (Pic. 16). A grazing calendar, considering the areas and conditions of the paddocks, was developed. The calendar is provided in Table N1.



Map 3. Pilot pasture in Naniani village located south of the S5 highway, near the Mkrali Ole river

Map 4. Scheme for dividing the first site of the pasture in Naniani village into paddocks

Pic. 16. Installing electric fencing

Table N1. An example of a grazing calendar for the first site of the Naniani pasture (sample)

Paddock	Area, square meters	Square meters per animal per day of grazing	Number of grazing days in unit per animal	Number of livestock	Number of grazing days on paddock	Estimated grazing calendar days	First grazing	Second grazing	Third grazing
1	15990	150	106.6	59	2	2	1-2 August	1-2 October	
2	17012	150	113	59	2	2	3 – 4 August	3-4 October	
3	8699	150	57	59	1	1	05 August	05 October	
4	11595	150	77	59	1	1	06 August	06 October	
5	14049	150	93	59	2	2	7 – 8 August	7-8 October	
6	31270	150	208	59	4	4	9-12 August	9-12 October	
Alternative pasture		Use arable land plots after harvesting annual crops as alternative pastures, while in October - adjacent pastures located outside the fence				45	13 August - 30 September		
Alternative pasture 2									13 October
Total estimated grazing days on the pilot site				Total calendar days		56	**Minimum period for pasture restoration 45 days**		

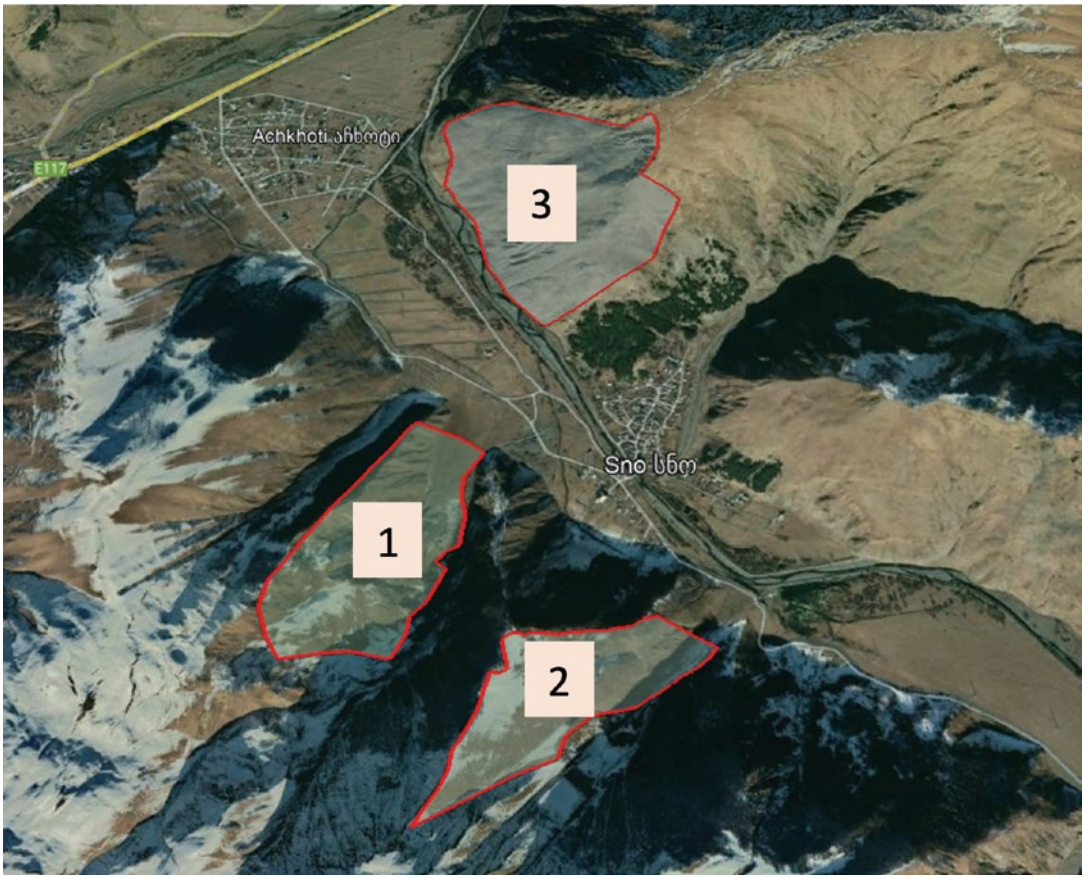
Data recording

A pasture monitoring program involving daily examination of the pasture's condition and data recording has been developed for each pasture. The condition of the pasture is monitored through daily records and photographs.

4.2 Pilot pastures in Sno village of Kazbegi municipality

4.2.1 The condition of pilot pastures before improvements

Three pilot pastures were chosen on the territory of Sno village (Map 5), covering an area of 208 hectares. The area of the pasture #1 is 57 ha (Pic. 17), the area of the pasture #2 - 37 ha (Pic. 18) and the area of the pasture #3 - 114 ha (Pic. 19).



Map 5. Pilot pastures in Sno village

Pic. 17. Pilot pasture N1

Pic. 18. Pilot pasture N2

Pic. 19. Pilot pasture N3.

The pilot pastures primarily serve the livestock owned by local community members. Occasionally, nomadic herds of sheep also graze in the area, particularly in the upper section of the pastures. However, the local livestock that permanently grazes in the area mainly consists of cattle, with the production of dairy products being the main economic activity for their owners. While a small number of community members also own sheep, their numbers are gradually decreasing. Additionally, there are a small number of horses and goats present.

During the grazing season, typically lasting from May to September-October, farmers only ensure that the cattle are driven to the pasture or simply open the farm gate in the morning. Throughout the day, cattle graze on their own and return home by themselves or are driven back by their owners in the evening. This practice leads to highly selective feeding, contributing to weed growth in the lower areas of the N1 and N2 pastures. However, the situation is relatively better on more productive pastures located on less steep slopes. These pastures are used by approximately 100-120 animals.

The first site of the pilot pasture is in an acceptable condition in terms of grazing quality and degradation, except for steep areas where cattle roam intensively. Here, the land cover rate is rarely below 75%, even in areas of intensive livestock movement.

The second site of the pilot pasture is steep and, therefore, intensive erosion processes primarily caused by glacial events are observed there. However, it is challenging to determine the extent to which grazing contributes to erosional processes.

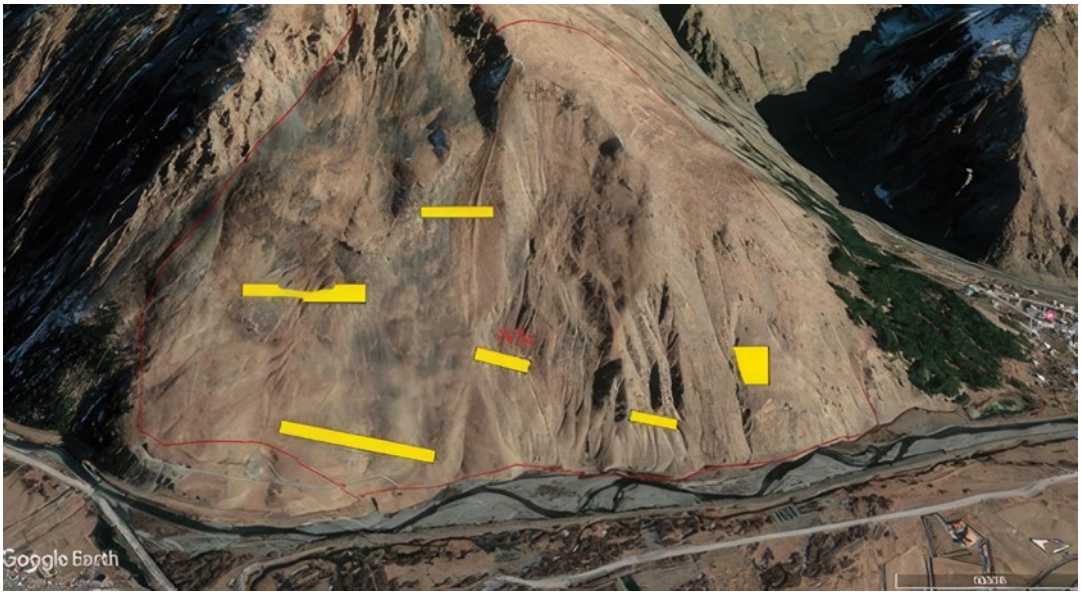
The grass species comprising the vegetation cover of the pasture are evaluated as suitable for the area, perennial, and suitable for animal consumption, with high nutritional value. Additionally, unlike other herbaceous species, these species do not significantly lose nutritional quality with maturity.

4.2.2 Improvement measures implemented on the pilot pasture

1. **Agroforestry measures**

The third site of the pilot pasture in Sno village is situated on a steep slope (with an inclination of 35-40°) and has relatively thin and stony soil. Because of its southern exposure, the soil tends to dry quickly in summer. However, the slope is supported by an artificial pine forest planted above the village. In certain areas, the natural spread of pine trees is already noticeable.

Planting trees on this slope is challenging; however, planting low-growing Caucasian pine saplings and sowing pine seeds is both feasible and recommended.



Map 6. Scheme of planting/sowing pine on the third pilot pasture

Improvement of pasture management practices

After discussions with the local population and based on the recommendations of international experts, a decision has been made to introduce a grazing system controlled by electric fences at site N2 of the pilot pasture in Sno village (Pic. 20) with the aim to demonstrate the advantages of this type of grazing to the local community.

Pic. 20. Installing posts for electric fences at site N2 of the pilot pasture

The lower section (57 ha) of site N1 of the pilot pasture in Sno village has been covered with gravel due to a landslide caused by heavy rains in the spring of 2023 (Pic. 21). Such floods and debris flows could substantially damage any infrastructure developed within the project area. Therefore, it is recommended to implement a controlled grazing system in the N1 pilot site, where a shepherd will manage the herd. To ensure proper time management and monitoring of the pasture restoration process, each site will be marked with wooden signs or painted stones. At this pasture site, to restore herbage, a hay cover was installed on the surface and silt blocks were placed to attract livestock. This approach avoided the early start of the grazing season, allowing plants to grow. At the same time, the hay facilitated seed dissemination, and the high concentration of livestock enhanced the accumulation of large amounts of organic manure.

Pic. 21. N1 pilot pasture in Sno village

Usually, pasture N3 (114 ha) is used only on rainy days. Accordingly, electric fences were not installed at this pilot pasture site, and only erosion control and agroforestry measures were carried out.

4.3 Pilot pasture in Ganakhleba village of Dmanisi municipality

4.3.1 Condition of the pilot pasture before improvements

A pilot pasture chosen on the territory of Ganakhleba village is located in Dmanisi municipality, north-west of the village (Map 7).

Map 7. Pilot pasture in Ganakhleba village

The pasture in Ganakhleba village has traditionally been used for continuous grazing of dairy cattle and was considered a good forage base for young cattle and partially for dairy cows.

According to field surveys conducted in 2019 and 2021, the condition of the pastures aligns with current grazing practices and management systems. The average vegetation coverage is over 95%. Most of the herbaceous plant species common on these pastures are characteristic of productive pastures.

The pilot pasture accommodates approximately 350 heads of livestock on a daily basis during the grazing season, spanning from May through September.

The area adjoining the pilot pasture is used by nomadic shepherds when driving their sheep to and from the high mountain pastures.

Every day, early in the morning, local community members drive their livestock to the pasture. The herd stays in the pasture during the day, and in the afternoon, they gather the livestock to bring them back to their stalls for milking. A shepherd usually manages the herd to prevent the animals from scattering over long distances.

4.3.2 Improvement measures implemented on the pilot pasture

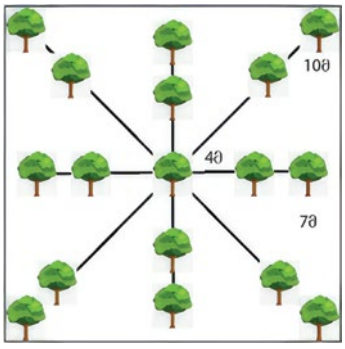
Installing watering point

5 watering points were installed on the pasture based on the location of paddocks (Pic. 22).

Pic. 22. Installing watering point on the pasture of Ganakhleba village

Agroforestry measures

As part of the project, a decision was made to introduce livestock sheds as an agroforestry measure. To build the so-called „green umbrellas," plants were selected based on local climatic and soil conditions. Specifically, 20 seedlings of narrow-leaved ash (Fraxinus coriariaefolia) and 14 seedlings of Caucasian Pear (Pyrus caucasica) were planted on the pasture according to the scheme shown in Pic. 23.



Pic. 23. Scheme of tree planting

According to the scheme, one tree was planted in the center, with four others in four directions at a distance of 4 meters. The middle trees were planted 7 meters from the center, and the outer trees at 10 meters. With 17 trees, one green umbrella was created, covering about 300 square meters and able to provide shade for 70-80 animals (Pic. 24). The green areas were fenced to protect the trees from livestock damage during the first years of growth.

Pic. 24. Planting livestock sheds on the pilot pasture in Ganakhleba village

To prevent the growth of woody weeds, young pine trees were manually removed from approximately 7 ha of the pilot pasture. (Pic. 25)

Pic. 25. Cleaning the pasture from young pine trees

Locating salt blocks on pastures

Salt blocks (Pic. 26) were located on the pilot pastures of Ganakhleba village. Salt blocks provide livestock with essential minerals, enhancing their productivity on low-quality pastures. Salt blocks help to attract cattle to stony and low-productivity areas and facilitate even utilization of the pasture.

Pic. 26. Locating salt blocks on the pasture in Ganakhleba village

Installing electric fencing

To implement the pasture management plan the pilot pasture in Ganakhleba village was divided into paddocks for rotational grazing. Of this, electric fencing was installed on only 35 ha to implement a controlled grazing system (Pic. 27). The fenced paddocks of the pilot pasture are separated by electric fences. The remaining areas of the pilot pasture are protected and used as alternative pastures when the restoration period of the herbage exceeds the periods specified in the grazing calendar. A grazing calendar, presented in Table N2, was developed in accordance with the areas and conditions of the sites.

Pic. 27. Installing electric fencing on the pilot pasture of Ganakhleba village

Table N2. An example of a grazing calendar for the first site of the Ganakhleba pasture (sample)

Paddock	Area, square meters	Square meters per animal per day of grazing	Number of grazing days in unit per animal	Number of livestock	Number of grazing days on paddock	Estimated grazing calendar days	First grazing	Second grazing	Third grazing
1	45076	130	346.7	56	6.2	6	July 1-5	September 1- 5	
2	33000	130	253.8	56	5	5	July 6-10	September 6 - 10	
3	59280	130	456.0	56	8	8	July 11 - 18	September 11-18	
4	18485	130	142.2	56	3	3	July 19 - 21	September 19-21	
5	68405	130	526.2	56	9	9	July 22 - 30	September 22 - 30	
6	34504	130	265.4	56	5	5	July 31 - 4 August	September 1 - 5	
7	26793	130	206.1	56	4	4	August 5 - 8	September 6 -9	
8	31785	130	244.5	56	4	4	August 9 -12	September 10 -13	
Alternative pasture1							August 13 - 31		
Alternative pasture2									From October 13
Total estimated grazing days on the pilot site			2441.0	Total calendar days		55	**Minimum period for pasture restoration 55 days**		

ANNEXES

Annex N1. Indicators for assessing pasture quality and definitions (adapted from LADA[20])

Core indicators		Category
1. Vegetation/litter cover		
1.1	**Total bare soil**	Percentage of bare soil on study area
1.2	**Bare spots**	ლაქები მცენარეულობის გარეშე
	None	None can be seen
	Little	Can be seen, but does not characterize of the area
	A lot	Characterizes the area
	Dominating	More bare than covered
1.3	**Litter cover on soil surface**	The more, the better soil surface protection [Gives an indication of moderate grazing practices]
	Dense cover	Covers soil beneath tufts
	A lot	Bare soil can be seen
	Little	Seen but no notable cover effect
	None	None seen
2. Vegetation quality and composition		
2.1	**Vegetation height, diameter and vigor for perennial species (shrubs, trees) and herbaceous species (grasses, legumes)**	Height and diameter (at breast height); vigor measurements: stem diameter, average shoot length and basal shoot diameter. Measured in a sample site and compared with the same characteristics of vegetation under optimal and poor conditions, taking the season into account.
	Good	Vegetation height, diameter and plant vigor is close to those of vegetation under optimal conditions.

20 LADA. Manual for Local Level Assessment of Land Degradation and Sustainable Land Management. Part 2. Field methodology and tools. FAO, 2016

	Moderate	Vegetation height, diameter, and growth strength are slightly below those of vegetation under optimal conditions.
	Poor	Vegetation height, diameter, and growth strength are significantly below those of vegetation under optimal conditions.
	Very poor	Stunted and defoliated growth pattern.

2.2	**Proportion of perennial /annual species**	Indication of grazing quality and resilience to drought
	Dominating	All grasses perennial
	A lot	Single annuals present
	Little	Perennials present but not important
	None	Perennials not seen

2.3	**Proportion of useful species**	These include species that perform ecological functions, e.g., canopy cover, deep rooting, resilience to drought, recovery, are edible and palatable, as well as species used by humans for food or healing
	Dominating	All or most species useful
	A lot	Moderate spread
	Little	Present – some useful species
	None	Not seen

3. Ecological integrity, biodiversity and change dynamics		
3.1	**Proportion of each vegetation strata**	%/proportion of trees, shrubs, forbs, grasses (reflects the level of exploitation of the pasture)
3.2	**Species that decrease with grazing pressure**	Identify those species that play an important role in livestock diet and decline with grazing pressure. To be compared with protected
3.3	**Species that increase with grazing pressure**	Identify those species that are known to increase with grazing pressure for each vegetation strata (grasses, shrubs and trees). These include species not (or not regularly) utilized by livestock and species resilient to trampling
3.4	**Poisonous plants**	Identify poisonous plants to livestock

3.5	**Alien Invasive or proliferous weed species**	Identify specific alien invasive (that are not characteristic for the area) or weed species that have reduced pasture area or productivity
3.6	**Pest damage**	Evaluate the extent and severity of damage by various pests (e.g., rodents, insects, etc.)
	None	Not seen
	Little	Single localities, no real damage
	A lot	Damage seen, but not over whole area
	Dominating	Whole area damaged
3.7	**Damage due to diseases**	Evaluate as in pest damage
	Core indicators	**Category**
3.8	**Shrub encroachment**	An increase in woody, invasive, unpalatable/toxic species on pasture. Too many bushes and trees depress grass production and may reduce access to water
	Sparce	Trees 30m+ apart
	Open	Visibility 200m and more
	Dense	Visibility 50m. People and livestock can still move with ease
	Very dense	Not easy to penetrate
3.9	**Deforestation**	Deforestation is the loss of forests due to overcutting of trees. One consequence of deforestation is soil
	None	There are no signs of deforestation
	Some	There are some indications of deforestation, but the process is still in an initial phase. It can be easily stopped and damage repaired with minor efforts
	Moderate	Deforestation is apparent, but its control and full rehabilitation of the land is still possible with considerable efforts
	Severe	Evident signs of deforestation. Changes are significant, or even beyond restoration within reasonable time limits
3.10	**Biomass decline ***	Reduced vegetative production for different land use. Depending on the time of year, biomass estimates can be made and compared between poorly and well managed/protected sites to give an indication of reduced vegetation production - trees, grasses, shrubs.
	None	There are no signs of biomass decline

Some	There are some indications of biomass decline, but the process is still in an initial phase. It can be easily stopped and damage repaired with minor efforts
Moderate	Biomass decline is apparent, but its control and full rehabilitation of the land is still possible with considerable efforts
Severe	Evident signs of biomass decline. Changes are significant, or even beyond restoration within reasonable time limits

ASSESSMENT SYSTEM

After identifying the categories of pasture indicators (Table N1) pasture condition can be scored. For each indicator one of the columns is marked. Columns have the following values: column 1 = 5, column 2 = 3, column 3 = 1, column 4 = 0. Sum the number of marks in each column. Multiply it with the value of each column. Sum all to give a total index for each site. Convert the score to the percentage of the maximum score. Assess the condition of the pasture based on obtained percentage value using the Table N3.

Table N2

Pasture condition indicator		Best	Moderate	Poor	Worst
1.1	Total bare soil	None ❑	Little ❑	Lot ❑	Dominating ❑
1.2	Bare spots	None ❑	Little ❑	Lot ❑	Dominating ❑
1.3	Litter cover on soil surface	Dense ❑	Lot ❑	Little ❑	None ❑
2.1	Vegetation height, diameter and vigor	Good ❑	Moderate ❑	Poor ❑	Very poor ❑
2.2	Proportion of perennial/annual species	Dominating ❑	Lot ❑	Little ❑	None ❑
2.3	Proportion of useful species	Dominating ❑	Lot ❑	Little ❑	None ❑

3.1	Proportion of each vegetation strata (grasses, shrubs, and trees)	Dominating ❑	Lot ❑	Little ❑	None ❑
3.2	Species that decrease with grazing pressure	Dominating ❑	Lot ❑	Little ❑	None ❑
3.3	Species that increase with grazing pressure	None ❑	Little ❑	Lot ❑	Dominating ❑
3.4	Poisonous plants	None ❑	Little ❑	Lot ❑	Dominating ❑
3.5	Alien invasive or proliferous weed species	None ❑	Little ❑	Lot ❑	Dominating ❑
3.6	Pest damage	None ❑	Little ❑	Lot ❑	Dominating ❑
3.7	Damage due to diseases	None ❑	Little ❑	Lot ❑	Dominating ❑
3.8	Shrub encroachment	Sparse ❑	Open ❑	Dense ❑	Very dense ❑
3.9	Deforestation	None ❑	Some ❑	Moderate ❑	Severe ❑
3.10	Biomass decline	None ❑	Some ❑	Moderate ❑	Severe ❑
Score		**5**	**3**	**1**	**0**
Sum of scores					

Table #3

Score %	Pasture condition	**Trend (if any)**
90 – 100	Excellent	
71-90	Good	Stable
51-70	Average	Improving
31-50	Bad	Deteriorating
0–30	Extremely bad	

Annex N2. Site Data Collection Worksheet (adapted from PRAGA[21])

Name of evaluator/team	Evaluation date:

Site identification

Site name	ID or cadastre code of the site
Geographical coordinates of the site (GPS coordinates)	

Site description

Slope	Shape
(flat, gentle, medium, steep, sharp)	(convex, concave, straight)
Aspect (N, S, E, W)	
Predominant land use (grazing, browsing, cropping, forestry, protected area)	
Amount of precipitation in the study year: Draught Below average Average Above average	

Soil indicators

Surface crust is observable: yes / no can be broken by fingers: yes / no
% of bare soil: _____%
Erosion:
No signs / localized / widespread / insignificant / significant / strong

21 FAO and IUCN. 2022. Participatory rangeland and grassland assessment (PRAGA) methodology. First edition. Rome, FAO and Gland, IUCN.

Vegetation/biodiversity

Ground cover % (including vegetation and fallen leaves): 0 10 20 30 40 50 60 70 80 90 100% Palatable plants: None Some Moderate Lot Average grass height: 0-5 cm, 6-10 cm, 11-20 cm, 21 cm and higher Sign of seed formation: None Some Moderate Lot Dominating plant species:

Sets and values of participatory indicators

Presence of invasive timber species within 5 m: Yes/No Other:

Annex N3. Pasture management objectives worksheet

Pasture management objectives

Site name: Municipality: Code:

1. What was the land previously used for? If it was used for grazing, how many grazing days are estimated?

2. Briefly describe the objectives of the land unit management.

3. Formulate key considerations and management issues related to land management, including limited water availability for livestock, bare soil in some areas, salinization problems, low productivity, bush encroachment, etc.

4. What are the root causes of these problems?

5. Briefly describe the optimal grazing scheme for the given pasture unit.

For example: The grazing season starts in March. To minimize grazing pressure on available grass and early growth of invasive shrubs, livestock spend only 3 weeks on the pasture. They return to the pasture at the end of May to graze on the available herbage, remaining for 2 weeks. In August, grazing is particularly heavy and intensive, with cattle consuming remaining grass while leaving some on the ground. Moving shade structures ensures even distribution of manure. Leaves and bark of invasive shrubs are edible or clean at the base during this time, allowing for manual cutting and stacking of bushes to reduce fire risk and prepare pastures for fall rains. The last grazing stage occurs in November, during which cattle graze newly grown grass for 2 weeks.

Annex N4. Annual Grazing Action Plan

Annual grazing action plan

Site: Municipality: Code:

1. What changes have been observed in the pasture unit compared to the previous assessment? (See photo archive and field plot data if needed)

2. Is there a tendency of pasture improvement considering the set goal?

Yes / No

3. Is the impact of the current management practice negative or positive?

4. What adaptation measures or changes should be implemented this year to enhance last year's results, if any?

SUSTAINABLE PASTURELAND MANAGEMENT