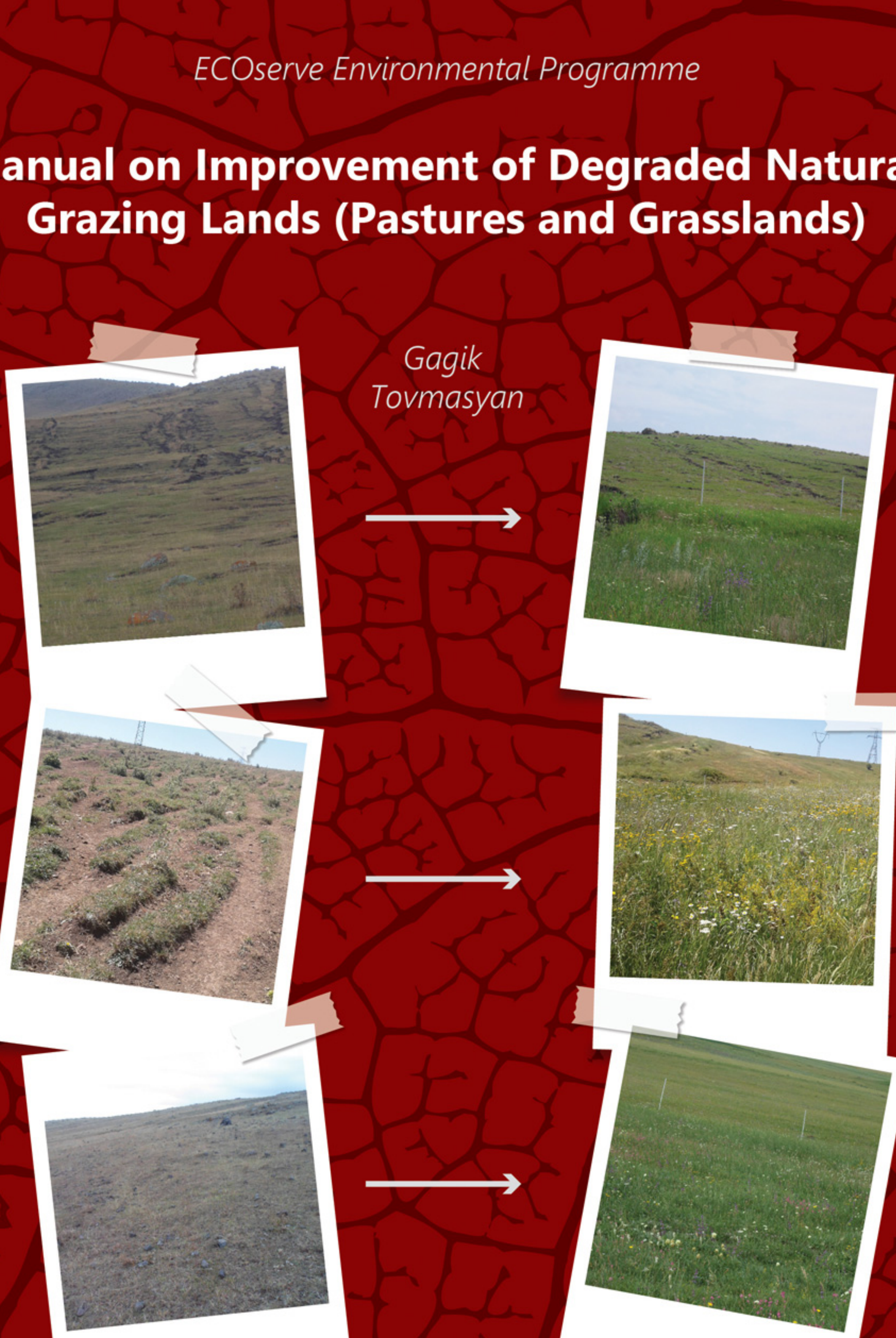
ECOserve Environmental Programme

Manual on Improvement of Degraded Natural Grazing Lands (Pastures and Grasslands)

Gagik Tovmasyan



Ministry of Territorial Administration and Infrastructure of the Republic of Armenia

Ministry of Economy of the Republic of Armenia

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DEUTSCHE ZUSAMMENARBEIT

Implemented by:
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ECOserve Environmental Programme

Manual on Improvement of Degraded Natural Grazing Lands (Pastures and Grasslands)

Gagik Tovmasyan

YEREVAN 2020

Manual for improvement of degraded natural grazing lands

The goal of the manual is to promote the development of integrated measures aimed at restoration and improvement of degraded and depleted natural grazing lands (pastures and grasslands) of Armenia, based on justified scientific approaches.

The manual discusses processes of planning and implementation of measures based on fundamental methodologies aimed at improvement of degraded natural grazing lands. It may become a general guideline for planning of restoration measures on degraded landscapes, development and implementation of improvement works, which will significantly contribute to increase of quality and productivity indicators of the grazing lands, restoration of degraded ecosystems, as well as improvement of the system of pasture and meadow fodder production.

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Preface

The ecological systems and their biological diversity are the bases for economic growth and sustainable development. Gradual loss of biodiversity today brings significant reduction in ecosystem services, hence negatively impacting economic well-being and environmental sustainability. For centuries the excessive consumption of natural resources has substantially disrupted the balance of the ecosystems. In result, the latter have underwent modifications. The well-being of the planet's population will largely depend on the conservation and restoration of the ecosystems in the coming decades.

Natural grazing lands are currently degraded (deteriorated, depleted, devaluated) ecosystems, which results in gradual decrease in plant and animal productivity. The capacity of the natural grazing lands to produce feed for the livestock sector shrinks continuously, because of weaker fertility of the soils and loss of pasture lands. Global climate change in its turn makes the aforementioned issues even more acute, hence generating significant additional pressure upon the ecosystems, including the natural grazing lands.

The struggle against the depletion of lands and landscape vegetation, and the improvement of the latter are priorities for protecting biodiversity and ecosystem services, which are of vital significance for life and well-being of the humanity. Timely planned and implemented actions, aimed at stopping the ecosystem degradation and improving them, may guarantee the provision of food, feed and water, contribute to better climate adaptation and reduce various conflicts and migration (resettlement).

It is necessary to implement actions aimed at restoration and improvement of degraded ecosystems and support the enhancement of such actions. They will contribute to protection and sustainable use of biodiversity, and also ensure safe food and water, employment opportunities and less poverty, will promote the conservation of natural capital (treasure), augment the fight against land degradation and desertification and become a measure to enforce climate change adaptation and prevention.

Armenia is a country of mountains with vertical zoning of soils and vegetation, established on diverse geological structures and complex landscapes through unique history and ecological developments. Armenia is rich with different bioclimatic habitats that create good conditions for establishment of natural landscapes with diverse vegetation, where characteristic Caucasian biodiversity has been flourishing for centuries.

About 57% of agricultural lands, registered in the administrative territory of the Republic of Armenia are grazing lands (pastures, grasslands). Apart from their environmental value, these lands are of unique and decisive significance for the agricultural production, especially livestock development, as they are the main source of feed. Pasture plants and grass resources ensure forage for satisfying the feeding in summer and nursing calves in winter with hay, comprising 65-70% of total feed demand.

While underlining the big importance of grazing lands in promoting production, it is worth mentioning that most of them are in dismal conditions, and their total productivity is incomparably lower than being satisfactory. This issue mostly comes from irregular and not systematized grazing (overgrazing, haymaking, wild collection) for years, in result of which the gradual depletion of vegetation cover created serious problems on natural landscapes and aggravated the qualitative and quantitative indicators of the vegetative cover and created serious prerequisites for threatening biodiversity and contributing to land erosion. Apparently, that is the main reason why degradation processes and land erosion thriving in plenty at all landscape zones (separate parts) of the country create serious dangers for sustainable and regular development of environmental systems and ensure a conducive environment for occurrence and development of desertification. The progress of such negative environmental phenomena may be mitigated by proper management, self-restoration, whereas the elimination of consequences may happen through special measures (improvements), in cases when self-restoration is not at all possible. This is all important economically, and especially environmentally.

In the period from 2013 to 2015, in support to the Government of the Republic of Armenia, the "Manual for Pasture Monitoring, Armenia" and the "Guidelines for Development and Implementation of Pasture and Grassland Sustainable Management Plans" were developed in the frames of Environmental programme implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). Methodologies and functions mentioned in the aforementioned documents have already been practically implemented in the sector of management of natural grazing lands in the Republic of Armenia. The developed manual and the guidelines describe the set of the main functions for sustainable management of biodiversity, including the monitoring, evaluation and effective use of the grazing lands. It is worth mentioning that implementation of improvements through artificial measures, as necessary, is among the integrated management functions.

In consideration of the necessity to restore and improve the degraded parts of the natural grazing lands of the Republic of Armenia, and taking into account issues raised by the rural communities related to the fundamental necessity to establish guiding principles for implementation of the aforementioned works, GIZ supported the development of the mentioned guidelines. The establishment of the guidelines satisfied the need to have a complete required set of measures and technical functions as parts of a methodology in the sector of integrated management of natural grazing lands on the community level (Figure 1).

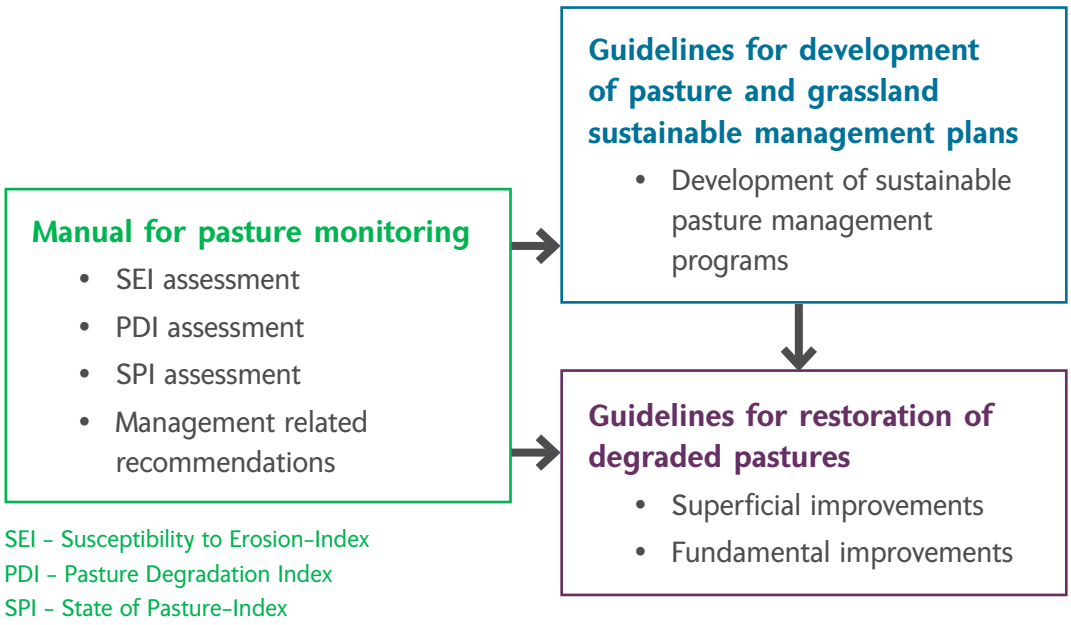


Figure 1: Methodical guidelines for integrated and sustainable management of natural grazing lands

The guidelines refer to processes of planning and implementation of measures, included in a scientifically justified methodology, aimed at improvement of the degraded natural grazing lands. It may be used as a general guiding document, envisaged for designing, development and implementation of improvement measures on degraded landscapes.

Artificial measures, aimed at restoration and improvement of degraded sections of combined vegetative covers, including natural grazing lands, are based on the methodology and specificities of systems of monitoring and management of pastures and grasslands of the Republic of Armenia, as well as procedures defined under resolutions of the Government of the Republic of Armenia (28.10.2010, #1477-N and 14.04.2011, #389-N), and the RA Law "On Flora" (1999).

The manual describes the necessary measures and techniques aimed at restoration and improvement of degraded pastures and grasslands. The methodology and the reasoning for their development emanated from operational functions justified both by international and national experiences.

The development of comprehensive projects and their effective implementation aimed at restoration and improvement of eroded and degraded pastures shall find solutions to such issues as:

- improvement of vegetative reproduction and qualitative indicators of degraded natural grazing lands,
- livestock forage on the pastures and mitigation of issues pertaining to livestock feeding in nursing periods,
- bbalancing the sustainability in development of degraded ecosystems,
- mitigation of possible risks (threats) occurring with vulnerability of endangered biodiversity,
- mitigation and prevention of degradation by means of extenuation of possible threats of erosion of natural landscapes,
- galvanizing carbon absorption through increasing vegetative assimilating surfaces, etc.

The methodical guideline is of high educational and practical significance for such target groups as:`

- research and education institutions,
- public agencies and non-governmental organizations implementing monitoring and protection of natural landscapes,
- regional authorities and local self-government bodies,
- pasture using farms.

1. Changes in economic and ecological conditions of the natural grazing lands, reasons for their occurrence and consequences

The vegetative cover of natural grasslands and pastures is not homogenous. It consists of diverse compositions of plant orders and classes that underwent evolutionary changes (incremental developments) to obtain adaptability to certain climates and established coexistences. The vegetative composition and the productivity (fertility) of such coexistences directly depend on the conditions of habitats and natural-historical and historical-economic factors that contribute to their establishment, in which case the ongoing struggle for life aggravates and changes the indicators of quality and productivity of the coexistences. Such changes are inevitable for natural grazing lands; they are influenced by natural-historical factors and are consequences of evolution. An irregular progress of changes is largely conditioned by impacts from economic-historical (anthropogenic) factors, as the industrial activity of men largely resulting in regressive change and various environmental issues, including occurrence and aggravation of degradation processes.

1.1 Characterization and significance of the natural grazing lands

Those sections of natural landscapes, where the vegetative cover mostly consists of perennials, semi-shrubs and shrubs are called natural grazing lands. They are used in agricultural production as sources of forage for organizing livestock summer and winter feeding.

Natural grazing lands are divided by vegetative and economic conditions, as well as types of industrial use into:

- pastures and
- grasslands.

The classification of the grazing lands by types of uses is performed through assessing the height of the growing plants, botanical species comprising the coexistences, variety compositions and indicators of productivity (fertility).

The diversity of natural conditions and the complexity of landscapes, but also vertical zoning established through different altitudes in the Republic of Armenia, create prerequisites for development of natural landscapes with rich and diverse vegetation that at all times had great significance and decisive role in livestock development, establishment of the necessary forage reserves and ensuring feeding. Apart from the industrial significance, natural grazing lands play even a more important role environmentally, as they create a climate, the sustainable development and growth of which is supported also by wild varieties of crops, as eloquent genetic resources (natural reserves) with a large share of endemic and relict (surviving) species.

Natural grazing lands (grasslands and pastures) are of great importance for ensuring the ecological balance in the environment, for conservation of biodiversity, establishment of fertile soil layers and favorable climate conditions.

These areas (pastures and grasslands) comprise about 57% of registered agricultural lands in the administrative territory of Armenia, and apart from their environmental significance they also have specific and decisive social-economic importance, because they serve as natural reserves and are used for production purposes, especially in organizing livestock forage management, preserving wild edible plants and medical herbs, promoting wild collection of seasoning spices, developing ecotourism, conserving and using the wild varieties of crops as genetic resources. The sustainable existence of

pasture and grassland ecosystems regulates the local water regimes and microclimates, prevents soil depletion, and ensures the use of ecosystem services, hence guaranteeing serious social and economic outcome.

According to the WWF biological index, ecosystem services provided by the natural grazing lands are globally assessed at US18.4 trillion.

Generally, the services (benefits) provided by pasture and grassland ecosystems are diverse in their nature and in their importance, as united under 4 main groups:

- delivered (resource),
- regulatory,
- auxiliary,
- cultural and health related.

The delivered services or the resource providing services include all the benefits received from natural grazing lands in forms of produce or stock. Among the delivered services more importance is given to pasture vegetation and hay that form the basis for livestock production. Among the service of this group we also have production of medical herbs, seasoning spices and edible wild plants.

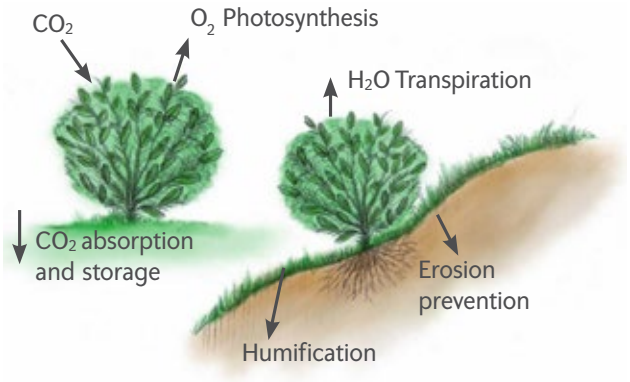
The regulatory services are the direct or indirect benefits obtained through regulation of ecosystem processes occurring on pastures and grasslands, where sufficient and conducive conditions are established for the existence and preservation of livelihoods of the population. Among such services are air quality improvements through transpiration and photosynthesis, climate regulation on local and global levels, purification and accumulation of surface and ground waters, processes of fertile soil layer establishment and humus generation, regulation of erosion and landslide processes, regulation of precipitation quantities and climate stabilization.

Auxiliary services are all the direct and indirect benefits that contribute to the remaining ecosystem services (soil formation, circulation of nutrients in soil, water circulation, photosynthesis, production of genetic resources of crops and transfer of biogenes).

Cultural and esthetic services are combined under establishing the necessary environment for tourism, wild collection, hunting and ecotourism.

Health care services include air quality and water purification, enrichment and climate establishment and sustainability.

Table 1. Ecosystem services ensured by natural grazing lands

Delivery of services	
Food	Providing for seasonal spices and edible plants
Feed	Production of pasture vegetation and hay
	
Medical resources	Producing herbs
Regulatory services	
	
Climate and air quality regulation	Evapotranspiration, photosynthesis and absorption of carbon dioxide
Water purification and accumulation	Regulation of surface flows, ground water feeding and evaporation
Prevention of erosion and soil fortification	Protection of fertile layer and enrichment of humus
Pollination	Species conservation, ensuring new generation
Mitigation of natural disasters	Mudflows, floods, landslides

Auxiliary services	
 Genetic source	
Habitat for species	Animals, plants, fungi and microorganisms
Ensuring genetic biodiversity	Genetic reserves of crops
Culture and healthcare services	
	
Leisure and recreation	Air, water, temperature
Tourism	Ecotourism
Cultural significance	Art, applied arts

Population well-being depends on diverse ecosystem services. The quantity and quality of services received through grasslands and pastures directly depend on the environmental conditions of those areas. About 60% of the world ecosystem services were disturbed in consequence of the human activity for the last 50 years. Degradation of those services continues now because of non-prudent use and improper management of natural landscapes, including natural grazing lands, highly supported by global climate change. Ecosystem services that were previously considered endless, are in fact limited and exist due to biodiversity, any disturbances of which result not only in effective reduction of such services, but to their irreversible loss in most of the cases.

Ecosystem services and benefits provided by pastures and grasslands of the Republic of Armenia have significantly shrunk, because of dismal ecological and economic conditions of those areas. The existing and persisting degradation phenomena on grasslands and pastures have their impact and consequences for diverse services (benefits) provided by those areas. The regulation of the issue, naturally supposes the development of a proper and well balanced policy for management of pasture and grassland ecosystems that will make the conservation, self-restoration and development of such systems possible.

1.2 Degradation of natural grazing lands; reasons and contributing factors

Natural coexistences occurring in nature do undergo alterations. Any new natural plant coexistence undergoes modifications through its whole life. Plant coexistences that develop under a natural process may change because of the habitat conditions (humidity, temperature, oxygen supply and light): Such changes may not only be progressive, but also regressive. Progressive change mostly happens through improvement in the habitat conditions. Regress can occur in a natural environment also, when vegetation growth is endangered or hampered. In case of regressive changes complex coexistences gradually replaced by more primitive forms, which results in immediate degradation of quality and productivity of the natural grazing lands. In such cases the grazing lands are slowly depleted.

Degradation is a phenomenon that originates and develops when various (natural and anthropogenic) factors influence the growth of vegetative cover on natural landscapes (pastures and grasslands), reduce the diversity of plant coexistences and the productivity (fertility) of natural grazing lands, worsen the quality of grass or other pasture vegetation, deplete the green cover.

Changes in the vegetative cover of the natural landscapes, including the grazing lands, that are expressed by gradual replacement of plant coexistences are preconditioned both by natural development of the coexistences and by external factors.

There are two main forms of replacement that takes place in plant coexistences:

- replacements through internal developments (endodynamics),
- replacements through external developments (exodynamics).

Natural replacements of plant coexistences that happen in a certain period of time and in the same habitat are called endodynamics. Any endodynamics replacement happening continuously in the same area and conditions is temporary, because in the process of natural replacement of coexistences, the impact of a new coexistence that had occurred even through progressive change creates new conditions for a habitat and results in gradual regress of grazing lands. Those replacements, through which regressive qualitative and quantitative changes of the vegetative cover in natural coexistences take place, are called exodynamic replacements. In this case the process of change of the plant coexistences depends on various factors, also external (climate change, landscape change, impact by humans and animals, wildfires, hay-making, grazing, etc).

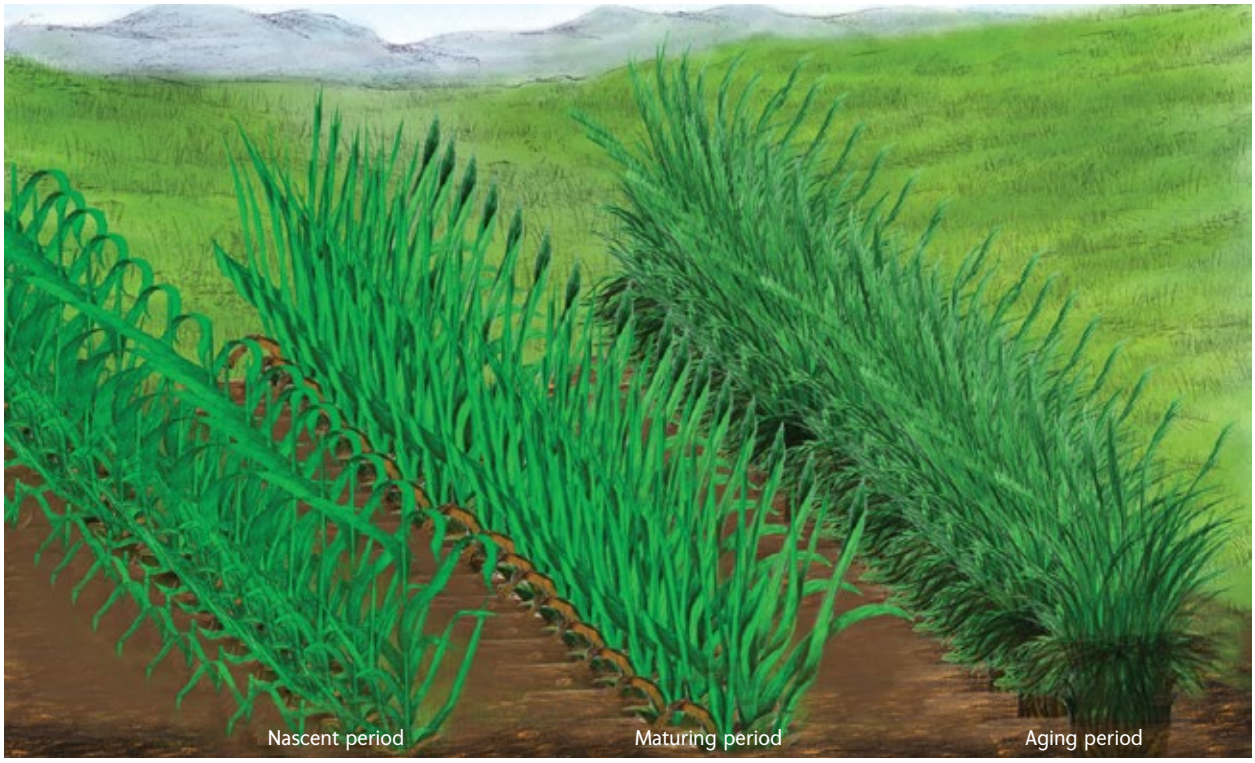


Figure 1. Regressive developments of the vegetative cover

As a rule, depletion and its progress at natural grazing lands are the consequences of regressive replacements of plant coexistences, the main reason for which is change in the habitat conditions under various factors. Changes in the conditions of the habitat may happen under natural and artificial processes. Hence, two main forms of degradation may occur on natural grazing lands:

- natural degradation and
- man-made degradation.

Natural degradation is slow and inevitable process that happens in nature (ecosystems) under the influence of natural-historic conditions. The main reason for it is the naturally happening replacement of plant coexistences in a certain habitat. In the conditions of such changes the vegetative cover of the grazing lands sometimes undergoes regressive developments and depletes. It means that reduction of both qualitative and quantitative indicators of the vegetative cover takes place, resulting in lower general efficiency and less productivity of the natural grazing lands.

Natural degradation of the grazing lands mostly occurs through densification of turf layer in the soil. The accumulation of dead roots, stumps and debris (decomposing vegetative mass on the surface) contribute to changes in physical properties of the soil, e.g. less water and oxygen penetration, densification in parallel to anaerobic (absence of oxygen) processes. The more valuable groups of vegetation undergo regress and are gradually replaced by less valuable species; hence the grazing lands lose their productivity and effectiveness. This process that occurs on natural grazing lands has three main phases:

- nascent,
- maturity and
- aging

In the nascent period the vegetative cover mostly consists of different family, genus and species of plants that are too demanding for soil and air quality, and mostly belong to the order of grains. Further aggravation of nutrition and air circulation conditions results in the rhizomatous cereals gradually withdrawing from the vegetative cover and being replaced by less air quality demanding

plants that grow well on solidified soils and still belong to the order of cereals. In this phase of development, when maturing, the grazing lands change in quality and essence.

Later, with accumulation of semi-decomposed organic matter, further aggravation of nutritional processes and air circulation, medium efficiency bunch grasses disappear from the vegetative cover and give way to even less efficient tussock grasses: When the latter appear on the grazing lands, the aging phase starts and ends with complete depletion.

Every subsequent phase of development changes the density and the biological composition of the vegetative cover of the grazing lands. This phenomenon mostly occurs with annual accumulation of dead matter (roots, rhizome and debris) on the surface and in the soil. In such cases, the slow decomposition of accumulating organic matter, which mostly takes place because of regress in microbiological processes and anaerobic decomposition, goes in parallel with increase of humidity in semi-decomposed organic matter, which then contributes to worse air circulation in the soil.

The vegetative cover of grazing lands undergoing the phase of aging is highly filled with tussock, less efficient species of grass and is mostly qualified as depleted. The overall plant cover of grazing lands in this phase of regressive development will significantly shrink resulting in higher evaporation from soil that contributes to activation of microbiological, including aerobic and anaerobic decomposition processes. In result, the layers of semi-decomposed organic matter (accumulated turf and debris) deplete and the soil is enriched with humus, the quantity of plant nutrients grows and the air circulation in the soil improves. In such a case, progressive development restores on grazing lands and low quality tussock coexistences will be gradually replaced by high quality rhizomatous and bunch grass coexistences.

Figure 2: Phases of natural process of change of vegetative cover

This inevitable process of changes on natural landscapes ensures one evolutionary-biological cycle, where the shift from regressive to progressive developments of the vegetative cover lasts 50-100 years.

The phenomenon of degradation that occurs naturally may have a more dangerous and ecologically negative impact on the environment currently, because of climate change and global warming. In such conditions the natural developments of formation of turf in meadows and pastures will inevitably result in disturbance of regular and ordinary balance, which will in their turn hamper the progressive processes of self-restoration.

Figure 3: Pastures degraded through natural processes

Figure 4: Extensive development of ranunculus sceleratus on natural grasslands

Man-made degradation occurs due to economic activity that leaves its impact on the environment. Compared to natural degradation processes, the man-made degradation progresses much faster and brings depletion of vegetative cover, replacement with less quality species and desolation of the grazing lands in much shorter periods of time. In result the efficiency and productivity (fertility) of the grazing lands reduce, threatening general biodiversity, hampering natural growth of ecosystems, which brings various environmental problems, like soil depletion and desertification.

The main reasons for occurrence of degradation on natural landscapes of the environment (grasslands and pastures), due to human activity are: incorrect use of natural resources (hay-making, grazing, wild collection), improper implementation of measures aimed at conservation and protection of vegetative cover, incorrect choice of time for organization and implementation of hay-making at grasslands, years of limitations on opportunities for self-restoration and nutrition of the vegetative cover, failing to ensure rotational use of grasslands. The degradation on natural grasslands occurs because of hay-making in the same periods of every subsequent year, which results in incremental withdrawal of a number of seed germination plants from coexistences and depletion of soils.

Man-made degradation in pastures mostly occurs and aggravates because of indefinite, irregular and continuous use of the vegetative cover (overgrazing), in ignorance of standards on permissible quantities of livestock per land plot (PQL).

When grazing is organized in the early stages, before the necessary growth of pasture vegetation has occurred, regular accumulation and consumption of sufficient reserve nutrients does not take

place, which results in less capacity of growth and less productivity. Additionally, grazing on pastures in early stages (in Spring, after snowmelt) negatively impacts the turf layer formation process, as in conditions of incompletely established vegetative cover extensive trampling (stomping) occurs and further solidifying the upper humid soil layer, changing its physical properties, water, air and nutrition regimes, resulting in regress of the vegetative cover, reduction of vegetative coverage and desolation.

Degradation develops faster on pastures with overcrowded livestock, in which case overuse of vegetative cover and excessive trampling of soil take place, resulting in barren lands (with no vegetation), stumped trenches and naked livestock drafting roads. Changes that take place in pastures so damaged are essentially irreversible. A lot of time and care will be required on order to develop the pasture vegetation to its initial or even more fertile conditions.

Generally, the main reasons for degradation on natural grazing lands are diverse and directly dependant on natural-historical and economic (man-made) factors. Depletion of landscape vegetation under the influence of the mentioned factors results in various environmental and economic (productivity) related issues that have consequences on the environment and the economy.

Figure 5: Depletion of natural grazing lands because of human activity

1.3 Environmental and economic consequences for natural grazing lands

The use and protection of vegetative reserves provided by natural grazing lands must not be conflicting, but closely complementing one another. Self-restoration capacity building shall go in parallel with the use of the vegetative cover of meadows and pastures. It is necessary to use the natural vegetation in a way that brings negative consequences of use to the minimum or complete absence. Irregular, indefinite and sporadic use of the vegetative cover, without following the fundamental requirements of pasture use, results in gradual depletion of the vegetative cover, reduction in coexistences of more valuable species, contributes to decrease of productivity and economic efficiency of the natural grazing lands, and final decomposition.

Aggravation of environmental conditions on degraded grazing lands is mostly expressed by poor biodiversity, reduced vegetative coverage and low quality plants, thus making the disturbance of ecosystem balance obvious. Changes of such magnitude result in different ecological consequences, e.g. soil depletion and desertification.

Figure 6: Erosion as consequence of poor vegetation

Quality of forage changes with the degradation of the grazing lands, the productivity falls, directly limiting livestock development opportunities. Livestock forage development process need significant efforts to ensure pasture and meadow feed production management. It defines how successfully the issues of feeding and nursing are sustainably solved during the pasture grazing period. Degradation changes the botanical composition of plant coexistences of pastures or meadows, reduces the percentage of edible plants in vegetation, increases the number of low quality and tussock plants, which in its turn diminish the economic value and productivity of the grazing lands.

Based on the level of threat caused by current and possible future environmental and socio-economic consequences of degradation of natural grazing lands, it is necessary to carry out complex measures aimed at conservation and restoration of the vegetative cover and plant coexistences in such areas. Those measures will create the opportunity to restore the disturbed natural balance of ecosystems, increase the productivity of grazing lands and enrich the qualitative composition of the vegetative cover.

1.4 Importance of restoration and protection of ecosystem services provided by pastures and grasslands

Current international strategic documents define biodiversity as a milestone in the life of ecosystems and the process of delivering exosystem services, as they are vital for the well-being of humans. According to certain studies, losses of biodiversity and degradation of ecosystems remain a concern; as the restoration of degraded ecosystems needs promotion and extension.

Implementation of artificial measures on local levels remains a must for restoring and stabilizing the regular processes of natural development in severely depleted ecosystems. Such interventions must rather be of recovering nature. They can mitigate and prevent risks of depletion, emerging through artificial and natural processes, they can also restore the balance in the existing ecosystems, create a generally favorable environment for restoration, improvement and gradual development of biodiversity, in which case the qualitative and quantitative indicators of expected and obtained services from the pastures and grasslands will be improved. The latter preconditions the well-being of the society and improvement of livelihoods.

Despite the high importance of natural grazing lands, the man-made activity, especially for the last 100 years, has significantly disturbed the regular development and conservation processes of the vegetative cover in many areas. Specific plant species and whole plant coexistences vanish from natural landscapes, making the deterioration of such areas evident, on hand with decrease in their economic value. Crucial and required is implementation of artificial measures by specialists, aimed at mitigation and elimination of consequences occurring through current environmental issues that arouse on natural grazing lands due to ecological-historical and especially economic-historical (anthropogenic) processes. Such intervention are aimed at mitigating degradation related phenomena, protection, reproduction and sustainable development of natural coexistences. Sustainable management, implementation of rehabilitation measures will improve the productivity of natural grazing lands and the quality indicators of the vegetative cover. All the aforementioned together shall be a sustainable guarantee for solving a number of socio-economic and environmental issues. Especially:

- sustainable development of ecosystems ensured, opportunities for natural growth of different components of flora that establish the vegetative cover will grow,
- risks endangering the undisturbed development of biodiversity will be reduced and limited,
- ecological balance of the ecosystems will be restored,
- soil formation and carbon absorption processes will be activated,
- the botanical composition and qualitative properties of the vegetative cover will improve,
- the productivity (fertility of grazing lands) will increase, and the quality of forage reserves will improve.

The implementation of well justified artificial environmentally important restoration measures on degraded grazing lands will significantly mitigate all the challenges related to disturbance of ecological balance in the environment. Artificial measures aimed at ensuring (economically required) care, protection and restoration will guarantee improvement of quality of natural vegetation reserves (pasture greens and grass) and increase of forage volumes by improving productivity (fertility) on natural grazing lands, which will solve the issue of forage for livestock and establish additional and stable guarantees for increasing the productivity of livestock itself. The regular implementation of artificial and well justified measures for ensuring necessary care, improvement and restoration on depleted grazing lands will provide for realistic and sustainable opportunities for increasing the effectiveness of services provided by pasture and grassland ecosystems and the development of their quality composition.

2. Methodology for improvement of degraded pastures and grasslands by artificial restoration

The term "improvement" is defined as restoration of resilience and reproductive capacity of ecosystems, landscapes, forests, pastures and grasslands, aimed at providing for food, feed, energy, well-being, carbon absorption, increasing adaptability, preserving biodiversity, preventing erosion, ensuring water supply and improving quality. The improvement of activity and productive capacities due to restoration of ecosystems must go in harmony with improvement of degraded ecosystems, as such improvement happens in natural ecosystems. Improvements of the landscapes target the re-establishment of such conditions that contribute to restoarion in natural conditions, with implementation of artificial measures if necessary.

The productivity of natural grazing lands (grasslands and pastures), the qualitative and quantitative indicators of generated products (vegetation) directly depend on the natural-historical and economic-historical (anthropogenic) impacts on the ecosystems. The insufficiency of factors of impact and the diverse expression thereof may, with time, significantly change the ecological and productivity related conditions of the natural grazing lands. Hence, diverse ecological problems, with negative consequences, occur and develop in the ecosystems. Ecosystem degradation is the most aggravating and full of negative consequences among the occurring ecological problems. In order to prevent degradation and mitigate the consequences of existing diverse environmental and economic problems, and restore the natural conditions, implementation of special artificial measures of improvement is crucial.

2.1 Ecological and economic significance of improving degraded grazing lands

Degradation as a phenomenon, apart from being an environmental issue, with its diverse expressions, directly and negatively impacts the volumes and quality of grassland and pasture ecosystem services (benefits). Occurrence and aggravation of degradation, as an environmental problem, not only threatens, but also significantly depletes the biodiversity of ecosystems, disturbs the regular development processes and ecological balance, which results in serious problems of economic character, for example aggravation of diversity and decrease in productivity of plants (fertility) on pastures and grasslands, as well as deterioration of quality of generated vegetative resources (pasture greens and grass). Reduction in general productivity of natural grazing lands, economically directly impacts the productivity of the livestock and creates serious problems for the development of the livestock sector.

Proper management of grazing lands (grazing patterns and hay-making) is of critical importance in prevention of possible degradation of vegetative cover on natural grazing lands, mitigation and limitation of possible consequences of degradation processes, in which case grazing lands will be protected when fighting degradation, the productivity and qualitative composition of the vegetative cover will further be improved.

Lasting effectiveness of natural grasslands and pastures does not depend only on botanical coexistences and the density of coexistences of the vegetative cover, but also upon the efficient use of generated forage reserves (pasture green and grass) and application of sustainable methods (measures) of necessary care for protection of vegetative cover.

Irregular management of grasslands and pastures contributes to occurrence and aggravation of degradation, and the continuous improvement of environmental and economic conditions of natural grazing lands supposes implementation of artificial measures, if self-restoration is no longer possible.

Artificial measures are aimed at ensuring favorable conditions for the growth of vegetation comprising coexistences, enrichment of biological composition of the vegetative cover and improving the production capacities of the grazing lands.

Artificial measures of restoration, implemented in a complex manner or separately on separate degraded grazing lands, with the purpose of improvement of general vegetative cover, increasing productivity and quality indicators were called "improvements".

Justified pasture and grassland management and use, as well as regular implementation of organizational and agrotechnical (improvement) measures aimed at conservation and productivity improvement of the vegetative cover (fertility, quality) are necessary preconditions for solving the issue of livestock feeding, establishing a stable and quality forage reserve and ensuring the sustainability of environmental conditions and ecosystems by the use of pastures and grasslands.

Such measures are of great importance and significance for sustainable management of natural grazing lands, because they contribute to the growth of high quality forage plants and enrichment of the vegetative cover, which results in lasting stability of environmental conditions and higher productivity of grazing lands. Such actions are signified in terms of reducing general risks of biodiversity development in ecosystems and increasing the productivity of grazing lands by ensuring the stable growth of coexistences.

Artificial measures aimed at protection and restoration of vegetative cover and turf layers of natural grazing lands, suppose implementation of various actions and mostly depend on results of baseline monitoring of the grazing lands, when studies and assessments of habitats and the vegetative cover reveal the existing environmental and economic problems.

Revealing problems helps in development of complex measures, the implementation of which solves ongoing problems, mitigates and improves negative consequences, resulting in higher productivity indicators of grazing lands and improvement of quality of the vegetative cover.

Scientific justification is a necessary precondition for criteria of choice of measures that were based on results, encountered while assessing the current conditions. Natural conditions of the landscape zones will decide the time frames for implementation of measures. The indicators of conditions of the grazing lands will be used to define the regularity of implementation and the complexity of measures.

2.2 Methods of improvement of degraded pastures and grasslands and the characterization of measures

Complex restoration measures implemented at degraded grazing lands (pastures and grasslands) that will ensure the restoration of natural conditions of grazing lands and provide for increase of productivity (fertility) thereof are called "improvements".

Improvements are scientifically justified organizational, agrotechnical, agricultural and hydromeliorative complex measures, the main issues in implementation of which are: improving the soil, water and feeding regimes, carrying out works for protection of the turf layer and enrichment of the vegetative layer, contributing to a higher level of regular development of ecosystems, increasing of the useful (vegetation) area of the grazing lands, ensuring the conservation and the productivity (fertility) of the existing vegetative cover, artificially creating high productivity grazing lands (pastures and grasslands) by sowing and improving the turf layer.

Works on improvement of degraded grazing lands are carried out in two methods:

- superficial and
- fundamental

The choice of method for carrying out works for the improvement of degraded grazing lands shall be based on comprehensive information on the ecological and economic conditions of the grazing lands, provided through carrying out a study and an assessment of the area (monitoring indicators).

According to the analysis of results of field monitoring indicators, erosion vulnerability (EV) and pasture degradation (PD) are calculated. Based on that calculation, decisions are made for the need to implement restoration measures and the necessary method of improvements is defined with justified measures. Complex programs are developed for implementation of necessary measures of improvement and effective deadlines for implementation are decided, together with frequency of implementation and sequence of actions. The justification for deciding the time period for implementation of measures was based on the conditions of the landscape zone and vegetative period.

Superficial improvements are agrotechnical, agricultural and hydromeliorative measures of restoration, aimed at protection of natural turf layer and vegetative cover, supporting the growth of botanical–economic coexistences and improvement of development conditions, enrichment of the vegetative cover, increase of the useful (efficient plant covered) area of the grazing land. They guarantee the general productivity and effectiveness (fertility and quality) and improvement of quality of production of grazing lands.

Superficial improvements do not suppose deterioration of turf layer and existing vegetative cover of the grazing lands. They mean implementation of agrotechnical, agricultural, bio–engineering and hydromeliorative measures, aimed at establishing favorable conditions for growth and regular development of the vegetative cover. Superficial improvement measures must be implemented at such degraded grazing lands that are yet in nascent or maturing periods (according to turf development levels), where the vegetative cover is in the level of rhizomatous or bunch phase of development and the total composition of cereals and legumes is not less than 20–25%.

The main objectives of superficial improvement measures are: improve the water, air and nutrition regimes of plants, meanwhile ensuring the protection of the turf layer and the vegetative cover, carrying out enrichment works, keeping the grazing lands in rhizomatous and bunch development phases for as long as possible, hence increasing their economic value.

The implementation of superficial improvement measyres is not economically efficient on severely degraded and deteriorated grazing lands, where the vegetative cover undergoes the tussock phase (aging). Fundamental improvement measures are necessary on such areas, where low value, less edible, harmful and toxic plants prevail (apart from highand meadows on steep slopes) and the natural conditions of soils are favorable.

Fundamental improvements are complexes of agrotechnical, agricultural and hydromeliorative measures that use plowing and destruct the vegetative cover and the turf layer of the grazing lands, and the new vegetative cover can be established only through artificial sowing.

Fundamental improvement measures must be performed on those degraded and eroded areas, where the composition of edible cereals and legumes comprises up to 10–15% and measures of protection are not effective in increasing the productivity and effectiveness of the grazing land and the landscape does not contribute to further development of erosion or landslides.

Fundamental improvements are permissible and justified on slopes of 15–17 degrees and mostly on plains, where the turf layer of the vegetative cover is relatively thicker. Fundmental improvement measures are counterindicated on steeper slopes, because the destruction of the turf layer and the plowing of soil will create favorable conditions for erosion.

In general, when planning and implementing improvement (rehabilitation) measures on degraded grazing lands, it is necessary to take into account the results of integrated assessments and studies (monitoring) carried out on similar areas, and only through the analysis of such results the necessary

improvement method and measures can be selected. According to baseline data obtained through monitoring, degraded pastures and grasslands may be classified:

- areas where temporary rest (temporary limitation on grazing and hay-making) is necessary to increase the vegetation, improve and enrich the quality composition and the productivity (fertility) and guarantee self-restoration through a natural process (see the management manual),
- areas that need protection and agrotechnical and meliorative measures of restoration (superficial improvements),
- areas where fundamental or rigorous agrotechnical and meliorative measures are required (fundamental improvements).

Table 2. Methods of rehabilitation of degraded pastures

Pasture conditions	Assessment criteria	Method of improvement (implemented measures)
Mild degradation **(PCI = 7.5)**	Average vegetative cover - 75-80%, high quality edible plants on vegetative cover - 40-50% and higher, dry trenches – up to 2-3%, harmful species, weeds not exceeding 3-4%, 45-60 species per 100sq.m. of land.	**Ensuring the opportunity for natural self-restoration** (prohibition for use/grazing for 1-2 years)
Average degradation **(PCI = 5.0)**	Average vegetative cover – 65-70%, high quality edible plants on vegetative cover – 25-35% and higher, dry trenches – around 10-15%, harmful species, weeds not exceeding 10-20%, 30-40 species per 100sq.m. of land.	**Superficial improvements** (Agrotechnical measures, complex agrotechnical measures for protection of the turf layer by planting mixed grasses through secondary sowing)
Severe degradation **(PCI = 0 -2.5)**	Average vegetative cover – 45-60%, high quality edible plants on vegetative cover – not more than 15-20% and higher, dry trenches – 20-30%, harmful species, weeds not exceeding 45-60%, 15-20 species per 100sq.m. of land.	**Fundamental improvements** (Destruction of the turf layer, complex agrotechnical measure, in addition to cultivation of mixed grass)

In the latter case it is necessary to separate the restorable areas by condition and planned measures, as follows:

- areas that must participate in rotational cultivation,
- areas that must be improved apart from rotational cultivation, by means of establishing cultivated or artificial grasslands (highland meadows, pastures established on steep slopes, flooded and eroded foothills),
- areas, where hydrotechnical, meliorative and agricultural measures and investments are required (on marshes, deforested and deserted lands).

For improvement of registered and separated degraded lands, it is necessary to justify and recommend a system of restoration and fundamental rehabilitation measures, by defining the order and effective time frames of implementation of measures.

All rehabilitation and improvement measures implemented on degraded natural grazing lands (pastures and grasslands) should mainly be implemented by methods, mentioned below:

- improvement of soils and water regimes on grazing lands (by means of irrigation, accumulation of humidity, watering or drying),
- improvement of air penetration – aeration of soils (application of effective methods for processing of soils and turf layer of the grazing lands),
- improvement and fortification of nutrition conditions (feeding regimes) of the vegetative cover of the grazing lands, by means of using organic and mineral fertilizers,
- increase of the useful area (area with vegetation) of the grazing lands (by means of removing bushes, trenches, stumps and stones),
- enrichment of botanical composition of vegetative cover with species of edible plants (valuable edible species and their mixtures, by means of primary or secondary sowings),
- improvement of productivity and economic use regimes and forms of the grazing lands (grasslands and pastures), for maintenance of lasting agricultural protection regimes and generating high volumes and quality of feed from the mentioned areas (the objective is to improve the forms of use of grasslands and pastures, ensure the necessary care and protection measures).

The justification of the aforementioned technological measures, the method of their implementation, the order and the definition of effective time periods are presented in two effective forms of implementation (superficial and fundamental).

2.3 Superficial improvement system for degraded grazing lands

The system of superficial improvements largely supposes protection and restoration measures, as well as increase of useful (vegetation covered) areas of the grazing lands, the comprehensive implementation of which will contribute to establishment of necessary and sufficient conditions for ensuring natural and regular development of the existing vegetative cover, enriching the botanical composition of plant coexistencies, in which case the productivity (fertility) and economic value of grazing lands will inevitably grow, the quality structure of the vegetation will improve, the disturbed ecosystem balance will be restored, hence resulting in favorable conditions for the development of general biodiversity.

The main objectives of superficial improvement system are:

- increasing the useful (vegetative) layer of the grazing lands,
- improvement of water, air and nutrition regimes of meadows' vegetation by fundamental measures,
- ensuring protection of the turf layer and reducing the possibilities for spread of meadow weeds,
- increase of vegetation and enrichment of species' diversity on shallow and depleted grounds,
- increase of productivity of grazing lands and improvement of quality indicators of the production,
- increase of productive value of the grazing lands.

Technological measures and works implemented for superficial improvement include:

- agrotechnical works,
- works for improvement of water and air regimes,
- stabilization–improvement of nutrition regimes,
- works on protection of turf layer,
- works for improvement of plant coexistences, enrichment through secondary sowing.

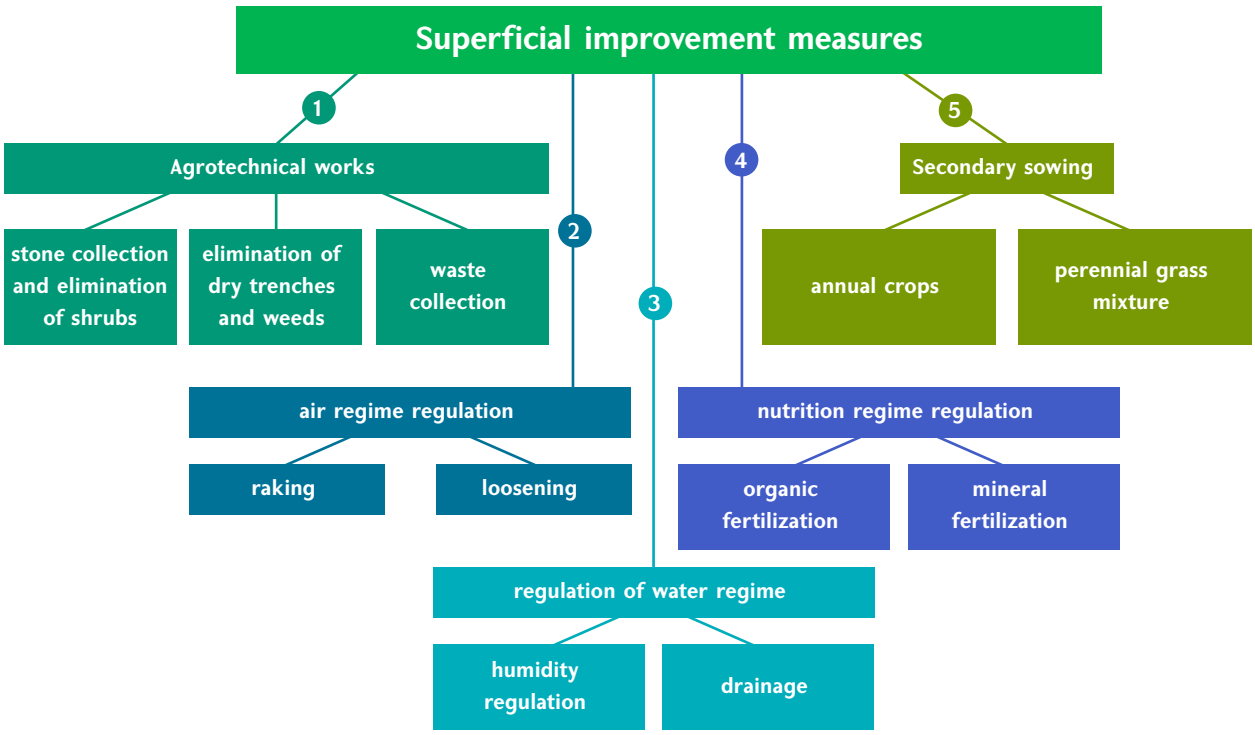


Figure 7. Superficial improvement measures

Agrotechnical works mostly include meliorative (soil improvement) measures, the main purpose of implementation of which is increasing the effective, useful (vegetation covered) surface of the grazing land, as well as ensuring the proper conditions of grazing lands for guaranteeing their productivity.

Larger part of natural grazing lands of Armenia (highland pastures) are stony, most of them are covered by low efficiency shrub vegetation and dry trenches of various origins, because of incorrect management. In this situation the useful surfaces of grazing lands significantly shrink, non-favorable conditions occur for use of agricultural machinery on grasslands, for growth and development of high-value edible plants. These issues result in lower productivity and economic value of grasslands and pastures with time.

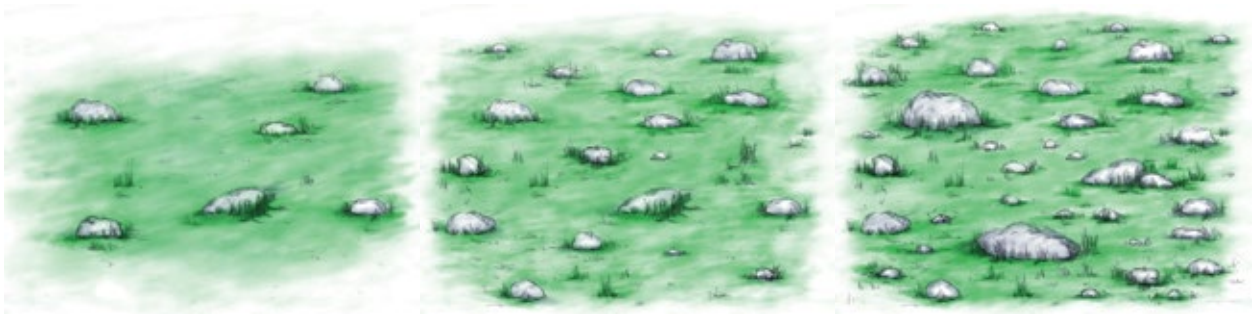
Agrotechnical measures include stone collection, elimination of shrubs and dry trenches of sundry origins, collection of debris, as well as works for improvement of areas affected by desertification (lacking vegetation).

Collecting stones: Significant parts of natural landscapes of Armenia are full of stones, depending on geological structure. In such circumstances the useful surfaces (vegetation covered feeding areas) shrink and livestock is injured when grazing. Stones on grasslands do not only hamper the use of harvest machinery, but also contributes to significant losses of yield, because hay is cut higher above the surface.

Organization of protection and restoration of grazing lands by stone collection is an important measure, the implementation of which increases the useful (fertile) surface of the grazing land, contributing to more opportunities for effective use. Stone collection requires an assessment of the level of stoneness, and respective organization of the volumes of works to be implemented.

By level of stoniness the natural grazing lands are classified into:

- weak stoniness (10% of the area),
- medium stoniness (20% of the area),
- high stoniness (40% of the area).

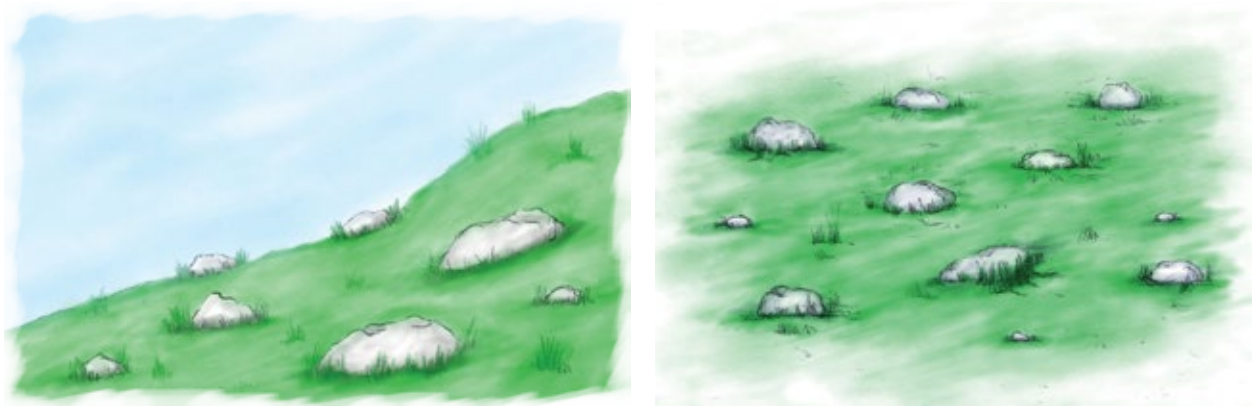


Weak Medium High

Figure 8: Stoniness levels

Stone collection is organized by hand and with use of equipment, depending on the level of stoniness and the sizes of stones. When organizing the stone collection special attention shall be drawn at the landscape factor and the depth of stones on the land.

On pastures and grasslands of medium and high steepness slopes only stones on the surface must be collected, collection of stones buried to their large parts in soil is counter indicated, because such actions may contribute to further depletion of the upper layers, more severe floods and gradual deterioration of the foothills. The piles of collected stones may not be left on grazing lands, but be removed and used for covering field roads, for filling dry trenches that occurred because of erosion, building soil protection ridges, and camping infrastructures for pasture use, e.g. watering points, overnight stay, etc. In areas, where stones were collected it is necessary to flatten the surfaces as possible and to carry out secondary sowing with mixtures of perennial plants, in order to ensure increase of the vegetative cover by establishment of new turf layers and coexistences.



Wrong stone collection Right stone collection

Figure 9: Permissibility of methods of stone collection

Elimination of shrubs: Cleaning of the lands from (productivity wise) low quality and harmful shrubs and semi-shrubs (paliurus, veratrum lobelianum, astragalus aureus, etc) is an important measure for the grazing lands under improvement processes. Removal of shrubs contributes to increase of useful areas of grazing lands, reduces the spread of harmful and toxic weeds developing on areas with shrubs, prevents spread of diseases and pests that can harm the vegetative cover of the grazing lands. The level of spread of shrubs and semi-shrubs on useable grazing lands of Armenia is especially higher on degraded sections above forest lines and prealpine zones, as well as on grazing lands of

southern slopes of steppes. Degraded sections of grazing lands in relatively lower altitude arid zones are especially favorable for Acantholimon Caryophyllaceum, Astragalus Aureus and Paliurus shrubs that also cause physical damage to livestock. Degraded zones above forest lines are significantly favorable for Spiraea.


Astragalus aureus


Paliurus spina-chrisiti


Onobrychis cornuta


Spiraea erenata

Increase in quantity of shrubs with time does not only reduce the useful areas of grazing lands, but also contributes to depletion and destruction of the vegetative cover. In areas where shrubs thrive meadow weeds (harmful and toxic plants) grow faster, and as they are not edible, they are not harvested and not used, and continue to flourish and spread the seeds. While gradually increasing their habitat (areas of existence), they deteriorate and deplete the existing vegetative cover, reduce the economic value and the general productivity of the grazing lands.

Cutting and removal of shrubs takes place during superficial improvements on such degraded grazing lands, where the shrub coverage is over 20-25% of the total area. If that percentage is higher, superficial improvement measures may be considered not satisfactory.

Figure 10: Pasture lands with shrubs

The cutting and removal of shrubs is performed by hand or special equipment (scissors). In order to correctly cut a shrub, it is necessary to cut at the base of stump, as it will grow back if you cut higher. The elimination of stolon-rooted plans must be repeated 2-3 times, because the rhizomes left in the soil can shoot above the soil layer again. Cutting shrubs is justified in the middle of the vegetative period, in midsummer. As in that period of time the base of the plant root is not rich with nutrition and any further growth of the plant may take place only partially.

Before removing shrubs it is necessary to study the area and the prevailing plant species. When analyzing the types of the shrubs identified, it is necessary to remove those plants that are of no economic value. It is not recommended and not even permissible to remove extinct or vanishing plant species, residual or endemic species, those of economic value, e.g. the rosehip, hawthorn and rhododendron. During the removal it is extremely necessary to pay attention to the ecosystem significance and specificities of biological diversity.


Roza


Crataegus L.


Rhododendron caucasicum

Depending on the landscape, the removal of shrubs must be carried out in consideration of certain consequences. Especially, the removal of shrubs from steep slopes must be performed with a special method, in order to prevent the possible future erosion of the land. Low quality shrubs have to be removed from such lands in the beginning of summer, right after the end of active precipitation period. Lands covered by shrubs must be fertilized and immediately cultivated, under secondary sowing techniques, by fast growing mixtures of legumes and cereals. Certain sections of lands with strong winds and covered by shrubs should better stay as they are, as protective layers that will save the meadows from winds. When removing shrubs from southern relatively dryer slopes, it may be necessary to leave certain sections of shrubs on ranges and horizontally placed on the slopes, as dams of soil protection and depletion prevention, as because of lack of humidity and rise of temperature, from the mid summer the vegetation rests and, as a rule, such slopes dry out and look naked, in which case the erosion phenomena activate in the beginning of fall, with more precipitation. In certain cases, massive elimination of shrubs can be performed by chemical mowing, especially by injecting special contact herbicides of local systemic significance. The elimination of shrubs by such methods creates serious risks in form of devitalization of certain plants species. An important precondition when using the herbicides is the correct selection of shrubs to be removed, because in case of stolon roots the use of contact herbicides is not justified.

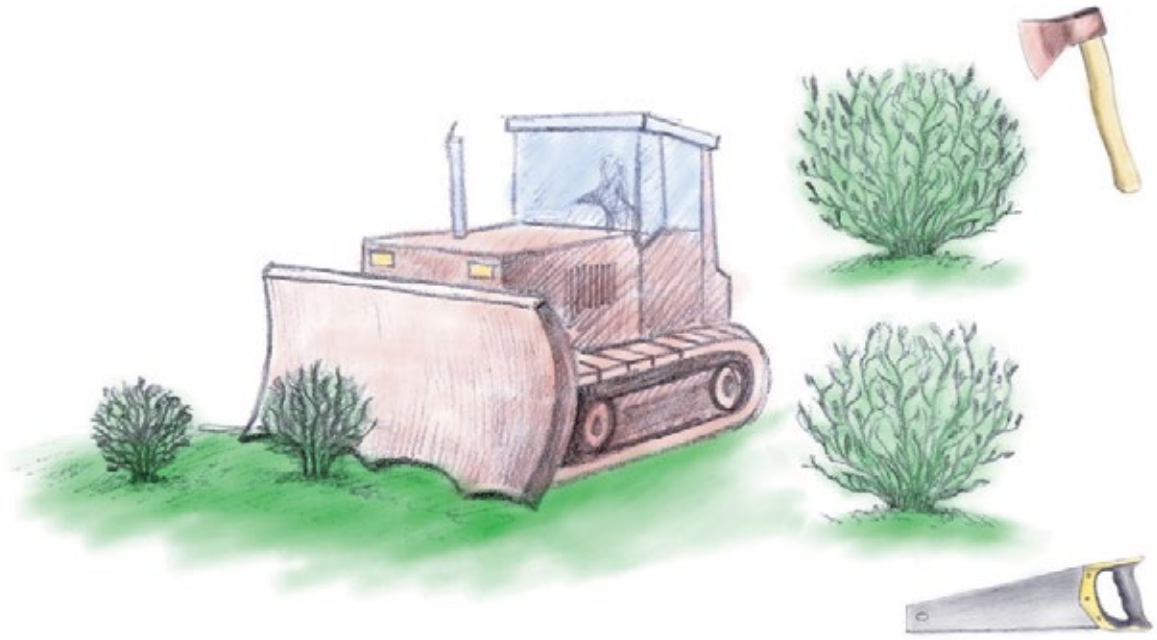


Figure 11: Mechanical ways of removing the shrubs

Eliminating dry trenches: When implementing superficial improvements or restoration and protection measures on grazing lands, it is important to eliminate dry trenches of various origins and types, the presence of which reduces the vegetative cover and the useful surface of the grazing lands.

By origin the dry trenches can be: trampled, stumped, stony, made by insects or moles, etc.

Figure 12: Dry trenches of various origins on pastures

Trampled trenches mostly occur on steep slopes and landscapes, in early spring or late fall (with higher humidity), when massive numbers of livestock are drafted to grazing lands without regular schedules, in which case trampled trenches with no vegetation, naked peaks and in forms of ranges appear on the slopes. The occurrence of the latter does not only contribute to less vegetation and less productivity of the grazing lands, but creates favorable conditions for the development of erosion phenomena.

Figure 13: Highland steppes degraded with trampled trenches

Ridges of vegetative origin mostly occur on degraded grazing lands of prealpine zone that are in the aging (tussock) phase. In such areas, vegetative ridges rise from the ground, mostly covered by carex, juncus ad tussock cereals, e.g. Festuca sulcata, Festuca rubra, Nardus (matgrass, insular grass) etc. Vegetative ridges on steppes mostly occur due to Stipa capillata and Festuca sulcata.

Festuca sulcata E.

Stipa capillata

Figure 14: Trenched highland steppes covered by Stipa capellata

In humid conditions of lands above the forest line and prealpine zones trenches area caused by mossy stones and stumps of logged trees, as well as rodents, ants and moles that build their homes and create sand piles of various sizes on the surface of the grazing lands. The presence of trenches does not only reduce the useful surface of the grazing lands, but hampers the use of harvesting machinery on grasslands and hence contributes to loss of harvest, because of cutting the grass higher above the surface.

In order to prevent the occurrence of the aforementioned problems, mitigate and eliminate the consequences thereof it is necessary to prevent the occurrence of trenches, but if they exist, then implement measures for their eradication.

A preventive measure for early spring and late fall humid periods is limitations on lasting grazing period in pastures on slopes. It is necessary to prolong the rhizomatous and bunch development phases of the plants by raking and fertilizers.

If 15–20% of the total surface area of the grazing land is covered by dry trenches, then stone collection and trench flattening by raking may be necessary. In areas with trampled trenches raking and secondary sowing with perennial plans mixture must be performed in order to cover areas affected by desertification by vegetation, as soon as possible.

Figure 15: Elimination of vegetative, ant and mole trenches

Figure 16: Highland steppes without vegetation (naked)

Restoration of naked (without vegetation) areas: Superficial improvement measures are also implemented locally, to restore the vegetation.

Naked sections of land mostly occur at livestock collection points, watering stations, as well as in the surroundings of distant pasture cabins, where livestock gatherings take place. Such areas lose vegetation gradually. Trampling harms the high quality plants and the area becomes favorable for weeds to grow. Restoration of such areas needs raking and secondary sowing, together with fertilization. In order to restore the vegetation fully time will be needed to limit the gatherings of livestock on them and establish rotational regimes.

Fighting weeds: The quality of pasture feed and grass obtained from natural grazing lands, also the volume of forage produced therefrom depend on the composition of the vegetative cover. Changes in the vegetative composition of degraded grazing lands depend on occurrence and spread of low quality, harmful and toxic plant species, the absence of control over development progress and growth of which will result in expansion of habitats of weeds and reduce the economic and ecological value of the grazing lands.

All plants that belong to various plant families, but are not edible (are not soft, not good for eating, harmful or toxic) and also cause bodily harm or poison livestock apart from aggravating the quality of pasture greens are considered weeds on the natural grazing lands.


Ranenculus sceleratus


Hyoscyamus niger L.


Euphorbia esula L.


Thalaspi arvense


Cirsum setorum


Setaria glauca

Low quality weeds are highly spread on natural grazing lands of various landscape zones of Armenia, however mostly they thrive on deteriorated pastures and grasslands.

Protection and rehabilitation works on natural grazing lands are of importance. Organization of measures against spread and development of weeds on meadows will doubtlessly improve the botanical composition of the vegetative cover and the quality indicators of growing vegetation. Works planned for removal of weeds mus take into account the types of grazing lands, the botanical composition of the vegetative cover, the landscape and the conditions of the turf layer, in order not to harm the vegetative cover of grasslands and pastures by implemented measures and not to create favorable environment for erosion.

A rather safe and effective measure against the weeds is mowing before they drop the seeds. By organizing and implementing early mowing on lands (especially grasslands) covered by weeds for 2–3 years, it may become possible to reduce the quantity and further spread of perennial and seasonal (toxic and harmful species of) weeds that reproduce by seeds. Regular mowing in the early vegetative periods will not allow the weeds to accumulate the necessary nutrition reserves for growth and survival in summer depression (droughts) and they will dry out. Yanking the weeds with roots, use of chemicals for elimination, early mowing and rotational use of pastures and grasslands for grazing are among the measures for fighting weeds. Raking on grazing lands may guarantee the best results time after time. In that case, the aeration of the upper soil layers improves and most of the weeds regress.

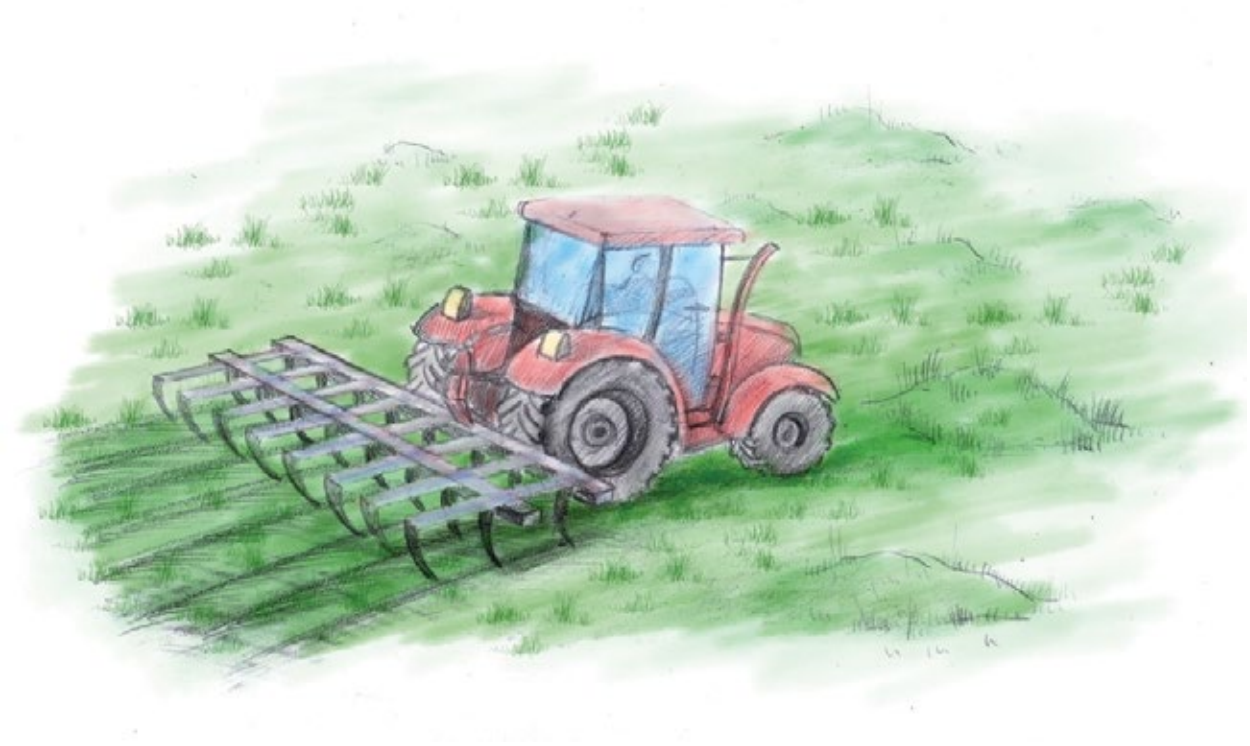


Figure 17: A measure against low quality tussock weeds

When organizing measures against weeds through chemical methods (herbicides), it is necessary to use contact or systemic chemical solutions with selective impacts, in order to eradicate the weed shrubs and semi-shrubs. Widespread use of herbicides is counterindcated for surface improvement works, as herbicides significantly damage the dycotiledone legumes and threatens the general biodiversity.

Elimination of dry debris and weeds by burning: Previously fires were used (as technological measure) to reduce the spread of low quality weeds and grasses, to get rid of dry debris (decaying matter) and improve the vegetative cover of degraded grazing lands. Fires were organized on degraded grazing lands with heavy accumulation of dry debris and weeds. The choice of the best time was important for fires. The permissible period for fires was early spring, right after the snow melted and before the plants started to grow. The debris that remained accumulated on the surface (in form of decaying matter) was completely destroyed by fires, together with the young shoots of weeds and the root bases of shrubs. Cereals and legumes were mostly not damaged by early spring fires. The vegetative cover of early and correctly burnt grazing lands predominantly contained grains and legumes.

The timely organization of fires on grazing lands that are heavily covered by weeds, toxic and harmful plants and semi-shrub vegetation, requires the implementation of all possible safety and warning measures, in order to avoid possible contingencies and complications. The probability of a burning field to grow into a wildfire must be brought to minimum by building bordering ranges.

The organization of fire on grazing lands in late spring or in fall is strictly prohibited. Fires for elimination of weeds and accumulated debris in late spring directly and negatively impacts the overall vegetative cover, because it harms the buds and shoots of edible plants. In such cases the ecological and economic conditions of grazing lands significantly deteriorate.

Fires on the fields in fall harm the plant nodes that prepare for winter sleep, damage the plant tissues (first leaves) that synthesize and assimilate reserve nutrients and contribute to elimination of high quality (rhizomatous and bunch) plants. Even if they partially survive, they still produce very few shoots in spring, which results in further degradation of grazing lands and decrease in their economic value. It must be taken into account that fires in fall are also prohibited, because the dry debris on the surface

of the soil is useful for accumulation of snow in winter and prevention of high velocity flows from snow melt (especially on steep slopes), hence contributing to penetration of water and preventing erosion.

Currently, the legislative regulations in the Republic of Armenia do not allow putting the fields on fire. There are administrative fines and responiblity, defined by the law, for organizing fires on grazing lands.

Improvement of aeration regime: With time the upper fertile layer of soil on grazing lands develops the turf layer and solidifies, the air penetration into the soil worsens and aggravates to insufficiency of oxygen (anaerobic conditions), the activity of aerobic microorganisms reduces and the absorption of organic matter slows down. In such conditions, natural depletion of vegetative cover occurs and drives the grazing lands to the aging phase (tussock development phase) and reduces their economic and environmental signifcance. Plant species accustomed to such conditions thrive.

Figure 18: Degraded meadows steppes with tussock vegetation

That issue also occurs on overgrazed and heavily trampled pastures, when aeration level drops because of lasting trampling events, contributing to degradation and deterioration of the vegetative cover and sometimes its complete loss and development of erosion phenomena.

Figure 19: Trampled steppes

This process of degradation, which is largely a consequence of reduced aeration, occurring due to natural and anthropogenic (man-made) factors, must be prevented by proper management or artificial interventions, aimed at preventing further development of degradation and mitigating the existing consequences.

There are various methods for improving the soil aeration regimes by superficial improvements or protection measures, and the most popular are raking and meadow cultivators (agricultural tool for soil loosening). The latter support the growth of high quality bunch and rhizomatous edible plants. Meanwhile, maintaining the grazing lands in nascent and maturing phases of development for a long time creates opportunities for ensuring proper agricultural conditions and increase of productivity levels.

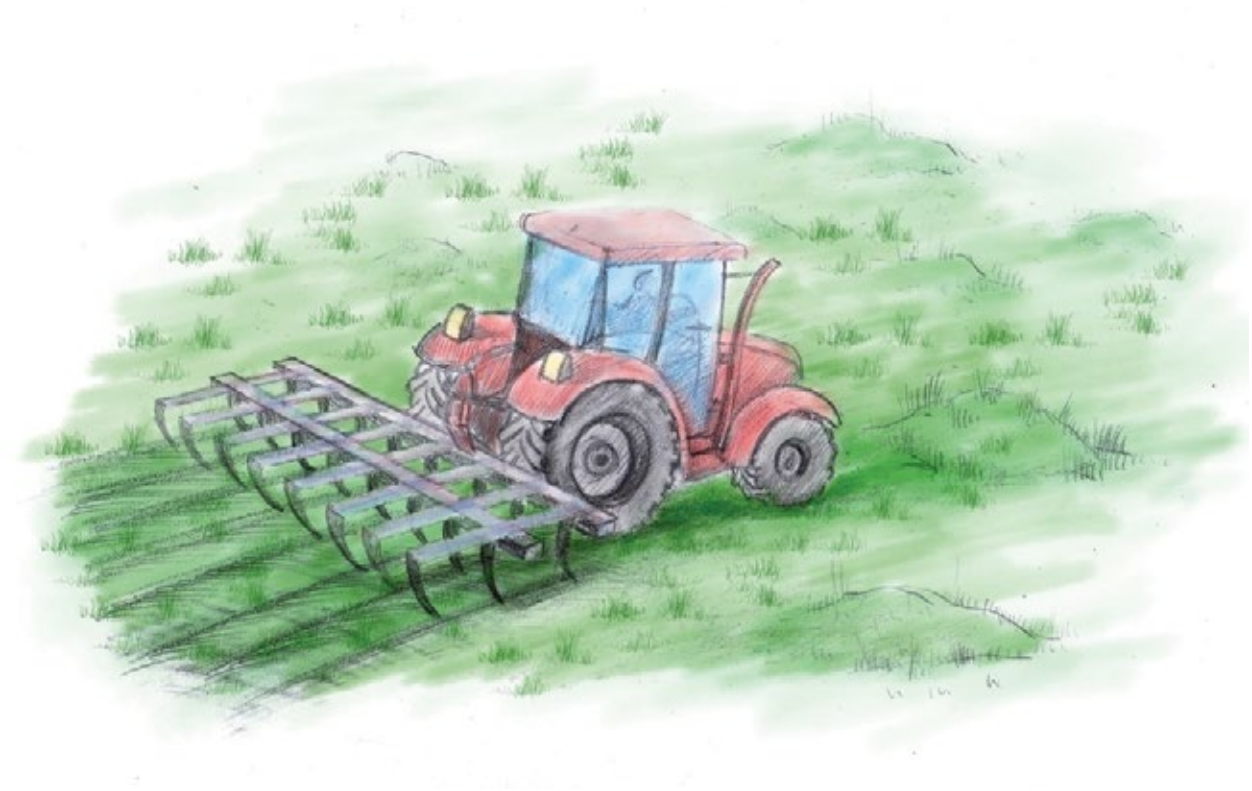


Figure 20: Improvement of soil aeration

Raking, as a measure to improve the soil aeration on various landscape zones, must be performed at different periods of time, with consideration of the climatic conditions of the area and the plant composition of the meadow. On grazing lands of higher altitudes (above the forest line and prealpine zones) raking may not be so effective in fall, as it loosens the upper turf layers and opens the root bases of plants and the lower tissues of the stem, which results in freezing and death of many plants in winter. Hence, raking of grazing lands on high altitudes must be performed in spring. In arid zones (semi-deserts or steppes) the raking of grazing lands in late spring is also risky, merely because naked buds on stems mostly dry out in summer.

On grazing lands with low levels of precipitation raking must be performed in early spring or in the end of summer, so that before lasting droughts or winter rest the vegetation adopts to new conditions and develops resistance capacity.

Raking on natural grazing lands must be performed by bow rakes or wheel rakes (wit depth of up to 5-6cm).

Figure 21: Grasslands' vegetation protection by raking

Raking by wheel rakes is more effective on lands with prevailing rhizomatous grains in vegetation, as their loosening and cutting contributes to more vegetation later, whereas wheel rakes are not effective on grazing lands rich with bunch cereals and legumes, because plants get damaged and the vegetative cover deteriorates.

In order to mitigate the processes of aging and deterioration on naturally degraded grazing lands, rejuvenate and improve the grazing lands regulation of the aeration regimes by loosening the turf layers may be considered the best measure if performed with the use meadow mills (trunnion transfer machines) or wingless cultivators.

Figure 22: Technical means for protection of the turf layer

In such cases loosening of 8–10cm depth contributes to improvement of aeration regimes. This measure supports the vegetative reproduction of plants. However, initially the vegetative cover of the meadow is significantly damaged, but later it becomes denser and richer, ensuring high productivity and quality indicators.

When applying raking for improvements on degraded grazing lands, the botanical composition and the condition of the turf layer must be taken into account, because in many cases the regulation of the aeration regimes by raking goes in parallel with physical damages of the vegetative cover and the turf layer, which can last for long – 1–2 years and negatively impact the general conditions of a meadow.

Better results may be achieved when the regulation of the aeration regime by raking is performed simultaneously with fertilization and improvement of the nutrition regimes, secondary sowing of perennial plants for enrichment of the vegetative cover.

Improvement of the nutrition regime: A plant nutrition system is the dynamic change between the levels of nutritional compounds in soil and the demand for such nutritional compounds by the plants during the vegetative period, in accordance with the changing requirements of the vegetative cover and the objectives of use of the vegetative cover.

Regulation of soil nutrition regimes by fertilization is among the most effective superficial improvements. Regress in development of humus layers on degraded grazing lands negatively impacts the growth of residual vegetative cover. Hence, the injection of available nutrition elements into the soil will significantly contribute to better growth of vegetation and increase of productivity. The use of fertliziers of various origin (organic or mineral) on degraded grazing lands will not only increase the productivity of the grazing lands, but noticeably supports higher density of the vegetative cover, improves the quality of harvest, changes the composition of species of the vegetation and regulates the micro flora of the soil.

Fertilization of the grazing lands increases the absorbed quantity of required nutrition elements in the soil, which brings later growth and increase in new shoots, because it also helps in complete accumulation of reserve nutrients for plants. The latter is the main guarantee for further development, enrichment and dense

growth of depleted vegetative coexistences. In care and protection and in establishment and regulation of soil nutrition regimes special attention must be paid to the following:

- botanical composition of the vegetative cover,
- climate conditions at the improved landscape zone,
- the indicator of available nutrition in the soil (defined by soil tests).

Depending on the type of the improved grazing land, the climatic conditions of the zone and the level of nutrition in soil, fertilization standards can be defined; various mineral and organic fertilizers may be applied. Favorable conditions may be established for further growth and development of the vegetative cover by both separate and combined uses.

Various organic and mineral fertilizers can be used for improving the nutrition regime. The time period and doses for applying such fertilizers depend on the quality of the soil, the level of vegetation and the botanical composition of the vegetative cover.

Figure 23: Fertilization by organic (manure) and mineral (nitrogen) fertilizers

Matured manure, manure slush, liquid manure and compost (organic fertilizer) have been applied more often. The use of manure is the most popular on natural grazing lands. The best standard for fertilizaing with matured manure is 20–25 tons per hectar of land. The best time for fertilizing the lands with manure is fall, before the establishment of stable snow cover. Manure must be dispersed on the grazing land, leaving it in piles is not effective. The dispersed manure will gradually disintegrate on surface and be absorbed in soil, hence supporting the activation of microbiological processes, accelerating the disintegration of accumulated and decaying dry debris on the surface, improving the soil structure and aeration regime. Fertilizing with manure has a significant impact on the botanical composition of the vegetative cover, it also contributes to increase of cereals and legumes and reduces the quantity of weeds and shrubs on the land. The advantage of using manure as a fertilizer is in the ability of manure to gradually disintegrate in soil and stay there for several years.

Fertilization with nitrogen, phosphorus and potassium containing fertilizers plays a significant role in regulation of soil nutrition regimes. The time, dosages and methods of their application depend on the level of degradation, the type of grazing land, the vegetative composition, the climatic conditions of the landscape zone and the level of composition of nutrients in soil.

A faster and more effective method of increasing vegetation of degraded grasslands and pastures, increasing the productivity and improving the quality is using mineral fertilizers. It is more effective to use mineral fertilizers (N, P, K) in combination and in reasonable dosages, based on the quantity of nutrients in soil. Phosphorus and potassium containing fertilizers are used in fall (main fertilization) and early spring (as additional nutrition). Fertilization in fall contributes to increasing the winter resilience of plant species growing in depleted vegetative cover, and to ensuring effective growth in early spring. Nitrogen containing fertilizers are mostly used in early spring to support the growth an in summer to provide for necessary nutrients. On certain types of grazing lands (cereals and mixed

grass), where the quantity of legumes is incomparably smaller, nitrogen containing fertilizers may be well effective when combined with fertilizers containing phosphorus and potassium. This method of fertilization contributes to accumulation of sufficient volume of nutrients in the reserves of the plants for surviving in winter, which will guarantee the winter resilience and ensure the sustainable growth in spring.

Provided grazing on pastures of certain landscape zones on Armenia continues till late autumn, in which case the perennials lose sufficient assimilation (growth) surface and fail to accumulate the necessary volumes of nutrients, it is hence more expedient and well justified to combine mineral (N, P, K) and organic (manure) fertilization in fall, which will guarantee sufficient volumes of required nutrients in soil and quick growth of plants in early spring, as well as fast sprouting and high productivity after grazing.

Measures for restoration of the vegetative cover on degraded and depleted grazing lands must be implemented in fall, before lasting frosts. Manure, phosphorus and potassium containing fertilizers are more effective when combined. If fertilization has not occurred in fall, the very first opportunity has to be used to apply all types of fertilizers (organic and mineral) in early spring, whereas the use of nitrogen containing fertilizers is the most effective in the growth period.

Mineral fertilizers per one hectar of land are 2.5 centners of ammonium saltpeter, 3 centners of ordinary superphosphate and 2.0 centners of potassium salt. These volumes are the best in average standards for increasing the vegetation of degraded pastures and grasslands, enriching the vegetative cover and significantly improving the fertility indicators, while not deteriorating the environmental conditions of the grazing lands.

It is worth mentioning that fertilization during the processes of restoration and improvement of the grazing lands is highly recommended and more effective to be performed with organic fertilizers (manure, manure slush, compost), in order to not only improve the quality of the soil and nutrient accumulation in plants, but also to prevent all possible negative impacts on the environment, which is obvious in case of lasting use of chemical fertilizers. The use of the latter must be strictly measured and planned, as it may have long lasting direct and indirect impact on natural resources (water, vegetation) and can create certain risks in terms of hampering biodiversity development and disturbing the general ecological balance of the environment. The use of organic fertilizers is widespread and significant for organic production (dairy and meat).

Regulation of the water regime: The humidity content in soil determines the level of vegetation of grazing lands, their fertility and the quality of harvest. The humidity factor on the administrative territory of Armenia is hughly variable: it may high in concaves and mountain plains, but much lower on foothills, watersheds and lowland arid zones. Improvement of soil humidity content by regulation of the water regime is decisive in increasing the productivity of grazing lands and improving the quality of the vegetation. When planning improvement and rehabilitation measures, especially for degraded grazing lands, it is important to increase soil humidity by implementing various measures in arid zones.

There are various measures for improvement of the water regime, e.g. irrigation, snow accummulation, regulation of surface water flows by creating estuaries, etc. The possibilities for regulating the water regime mostly depend on climate conditons and the water level of the area.

On natural grazing lands of lowland arid steppes regulation of the water regime depends on presence of irrigation that uses the surface flows occurring through natural precipitation (mudflows) and water resources of artificial reservoirs. Increasing soil humidity by artificial irrigation contributes to the change of vegetative cover, increase of density of plants and improvement of productivity indicators. Increase of artificial irrigation by accummulated waters from snow melt is an important measure on natural grazing lands of lowland zones with poor vegetation (semi-deserts, arid steppes), apart from

ordinary irrigation. It can be performed in all landascape zones by using portable screens (wooden dams, polyethylene nets) or by building natural (soil protection) cultivaion ranges on grazing lands. Portable wooden screens are mainly installed on windy lands in winter, hence contributing to acummulation of more snow. High growing plants are used to create cultivated ranges, e.g. sunflower and maze, planted in 3–5 rows on natural grazing lands. After the grown ray florets and the receptacle are harvested the peduncles remain on the field and increase the snow acummulation by becoming a natural dam. The accummulated snow reserve slowly melts and creates surface flows that are completely absorbed in soil and increase the humidity level, positively impacting the general conditions of the grazing land.

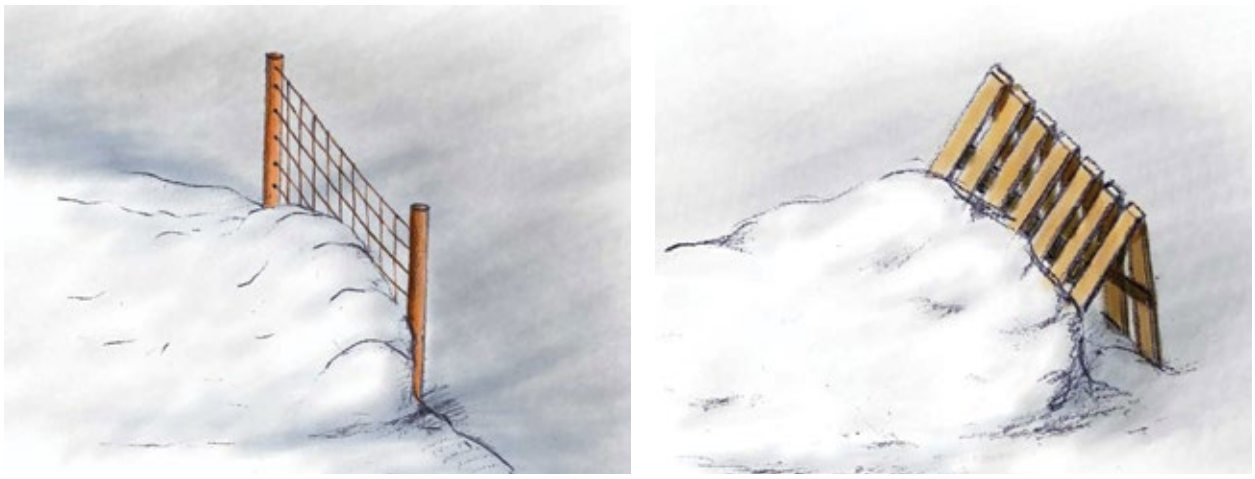


Figure 24: Snow accummulation screen and dam

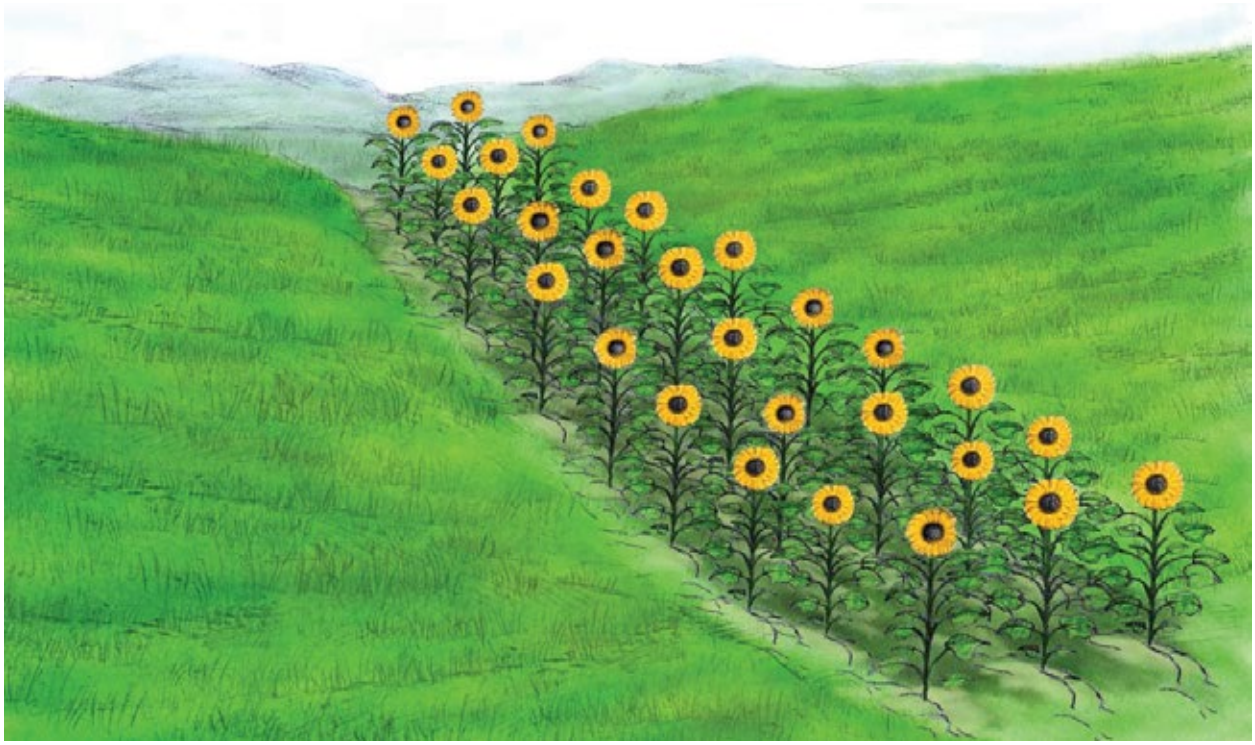


Figure 25: Natural cultivation range by high stem plants

Horizontal esturaries can be build in order to improve soil humidity and increase the humidity indicator on grazing lands on steep slopes. Building estuaries supposes digging 50–70cm deep culverts with turf covered sand walls. Surface flows occurring during spring snowmelt will accummulate in those canals, slowly penetrate the soil and increase humidity, enriching the vegetative cover and increasing the fertility level. Estuaries with several layers, at a certain distance from one another, may be more

effective depending on the length and the steepness of the slope. If the slope is not very steep, the distance between the estuaries must be larger, but if the slope is steep then the distance can be smaller. Building estuaries on steep slopes also prevents erosion. Estuaries with the acummulated water reserve can be used as temporary watering points for livestock on pasture grazing.

Figure 26: Estuary on steep slope

Sometimes water accummulates on mountain concaves after snowmelt and heavy rains, which if lasting may eliminate the vegetative cover. In order to solve the issue it is necessary to regulate the water regime by building drainage systems on wetlands; canals of 20–25cm depth can prevent swamping on concaves.

Figure 27: Open drainage from azonal wetlands

Works on restoration and protection performed through superficial improvements are important for maintaining groundwater table in aquifers, in order to avoid swamping of the turf layer in the future. The issue can be solved by establishing hydrotechnical structures on surface and in the ground, especially through building groudwater drainage systems and open surface drainage by canals and estuaries. The operationalization of such structures supposes reduction in groundwater table at a depth of 60–80cm from the surface, so that soil humidity of only 60–80% is ensured throughout the whole vegetative period, which is an important precondition for creating opportunities for development of vegetation.

In order to ensure sustainable pasture use on pastures restored by improvements livestock watering is necessary, i.e. installing watering points for the livestock. Natural surface and ground flows can be used for organizing the watering points.

Figure 28: Pastures with watering points

The spare quantities of running water on the watering points must also be used to irrigate the grazing lands.

Watering points build on relatively flat surfaces must be at a distance of 1,5–2km from one another, on steeper surfaces the distance can be 0,8–1,2km.

Enrichment of vegetation by secondary sowing (full repair): Technological measures aimed at enrichment of vegetation and increasing the density of plants on deteriorated and depleted grazing lands must be performed in consideration of increasing the number of good quality edible plants in the vegetative cover. The solution of this issue is in secondary sowing with mixtures of perennial, biologically compatible cereals and legumes on improved grazing lands.

Secondary sowing is an agrotechnical measure, performed on grazing lands with poor and deteriorated vegetative cover by means of dispersing seeds of various (biologically compatible) grasses in certain (predefined) quantities, without plowing the turf layer.

Secondary sowing on degraded pastures and grasslands of various landscape zones will significantly improve the botanical composition of the vegetative cover and increase the ecological and economic productivity of the grazing lands.

Secondary sowing is mostly performed with perennials, however, if the vegetative cover of the soil is too shallow, erosion may occur and develop, and in such conditions the cultivated mixture during the secondary sowing may also include annual plants, quickly growing grains and legumes (secale, vicia villoza) in order to establish a vegetative cover as quickly as possible.

Secale cereal L.

Vicia vilosa L.

When organizing secondary sowing with seeds of perennial plants it is necessary to consider the climatic conditions of the given landscape zone, make the right selection of plants and calculate the cultivated quantity standard in a mixture. The botanical composition of the ecosystem must be taken in to account when choosing the useable plants, in order to avoid compatibility and coexistence problems after cultivation (localization of cultures).

The following sequence of steps is recommended during the secondary sowing:

- assessment of the vegetative cover of the area, analyses of the compositions and relations of botanical–economic groups,
- selection of plants that can adapt and are compatible (cereals and legumes) with the habitat of the assessed landscape area,
- deciding the quantity of biologically compatible species of plants (cereals and legumes) in the cultivated mixture for the secondary sowing,
- defining the share and ratio of various plants in the selected mixture,
- calculation of the weighted share of seeds in the mixture, by percentage of selection,
- defining the quantity of seeds per a hectare of cultivated land, in accordance with the density of vegetative cover.

Seeds of perennial legumes and cereals are mostly used for secondary sowing, as well as seeds of valuable edible plants collected from the given area. When performing secondary sowing, attention should be paid to the current vegetation cover of the grazing land. If the composition of cereals is high on the vegetative cover, then only legumes will be selected in the cultivated mixture, whereas if various grasses prevail on the vegetative cover, then certain quantities of legumes and cereals can be used. The area must be prepared for secondary sowing and the time must be decided. In fall, after the completion of agricultural works on the improved grazing lands, at the end of the vegetative period, raking must be performed with use of main fertilizers (manure, phosphorus and potassium). Depending on the climatic condition of the landscape zone, secondary sowing with weighted shares of seeds can be performed in late fall or early spring. Seeding can be done both by rows (scatterer with ploughshares) and by ordinary broadcasting. In order to cover the seeds by soil it is necessary to carry out raking and flattening. On steeper slopes, where use of machinery is not possible, a traditional method can be applied for convering the seeds with soil, a sheep flock can be drafted over the cultivated plot 2–3 times. In spring, when the seeds germinate, fertilizing the area with nitrogen containing fertilizers may be necessary. In order to ensure and regulate the rooting of new plants grazing must be prohibited on the area for 1–2 years. It is more effective when the improved area is fenced, and the best option for fencing may be the electric fence.

One of the main issues in secondary sowing is the correct choice of plants in the mixture and calculation

of weighted share of the seed mixture to be sowed. The quantity of seeds to be cultivated must be decided based upon the density of the vegetative cover and the botanical–economic composition of the vegetative groups. In order to assess the density of the vegetation, the number of shoots on 1 sq.m. of provisional area must be calculated separately for 4 botanical groups (legumes, cereals, mixed herbs, sedges or carex). The total number of shoots of cereals and legumes, and 50% of mixed herbs must be considered as useful volumes. There may be up to 1000 shoots on every 1m2 (and 10mln. on a hectar) of a highly productive grazing land. The calculated number of productive shoots on a unit of area with secondary sowing is compared to the provisional number of shoots on a high productivity grazing land and the difference is filled with broadcasted seeds. In that case it must be taken into account that the sprouting capacity of seeds will comprise 50% in average, as about 20–25% of seeds sprouting in the first year will perish, hence 150 seeds will be required to produce 100 shoots.

The time period for secondary sowing mostly depends on the climate conditions of the landscape zone and the biological specificities of the selected plants.

In semi–deserts and dry steppes the best time for cultivation can be fall or early spring.

In meadow–steppes, prealpine zones and areas above the forest line the best time period can be early spring and early summer, when there is a lot of precipitation. If the legumes prevail in the mixture, then secondary sowing on all landscape zones is more effective in early spring. Using such a mixture for secondary sowing in fall can be risky, because of relatively high risk of winter frosts when the legumes germinate.

Secondary sowing on degraded grazing lands may be performed by self–seeding. On grazing lands with thin vegetation, with a few valuable edible plants growing and very few harmful and toxic species, stone collection and mineral (N, P, K) or organic (manure) fertilization may be required, with prohibition of mowing or grazing. In such a situation the plants will drop the seeds that will germinate on their own. In certain cases it may be reasonable to organize late grazing (after seeding and sprouting) on such lands, which will help dispersing the seeds and their covering with soil by trampling. Generally, grazing lands left on self–seeding may be improved by raking and fertilization in fall.

The secondary sowing and the possibility of self–seeding are the best measures for rejuvenating the grazing lands and increasing their productivity.

The principles of combining a grass mixture: Increasing and enriching the vegetative cover by primary and secondary sowing of selected mixtures of perennial edible plants that belong to various plant families is an important step in improvement of the grazing lands. As a rule, grass mixtures are established by combining perennial legumes and cereals.

Figure 29: Grass mixture

A number of properties have to be taken into account when establishing grass mixtures: the complexity of (the number of species in) a mixture, the duration of use of improved pasture or grassland, the type of use and the vegetative composition on the area to be improved by the grass mixture.

By complexity (quantity of species in a mixture) the grass mixture are divided into:

- simple (combined with 2–3 species),
- simplified (combined with 4–5 species),
- complex (combined with 6 and more species).

By type of future use of established vegetative cover:

- grassland,
- pastures,
- grassland–pasture.

Grass mixtures created to improve the grasslands by secondary sowing and create artificial grasslands by sowing must be mostly comprised of high growing plants (over 50cm of height). The grass mixture created for improvement of pastures must contain low growing, trampling resilient species. Whereas the grassland mixtures that are mostly used for creating agricultural landscapes, must contain both highland and lowland resilient plant species.

When establishing grass mixtures by purpose of use and natural conditions of the area, the correct choice of species will be necessary, while considering the shares of participation of each plant in the general mixture.

In order to improve the grazing lands by secondary sowing in lowlands and relatively arid zones (semi-deserts and steppes: 600–1600m above the sea level) heat resistant species must be selected with prevalence of grains (Zerna Inermis, Festuca Rubra, Asgroprion Crisitatum, Phleum Phleoides, Onobrichis Transcaucasica Grosh, Seinfoin, Lotus Corniculatus, Trifolium Hibridum).


Agropiron Crisitatum L.


Bromus
Inermis L.


Festuca
Rubra L.


Phleum
Phleoides L.


Onobrichis
Transcaucasica
Grosh

In areas of moderate humidity (meadow-steppes and areas above the forest line, 1800-2300m above the sea level) the grass mixture should contain more legumes (Trifolium pratense, Trifolium Ambiguum, միջին և Trifolium Repens, Onobrychis viciafolia, Vicia L., Dactylis glomerata, Festuca pratensis, Phleum pratense):


Trifolium
Hibridum


Trifolium
ambigguum


Trifolium
repens


Dactylis
glomerata


Phleum
pratense

In relatively humid, colder highland zones (prealpine zones, 2300-2700m of altitude) the shares of cereals and legumes in the selected grass mixture must be equal.

The sowing standard (the weighted size of seeds to be sowed on 1 hectare of land) and the calculation of the shares of participating plants (species) in the mixture are important.

The sowing standard per each participating plant in the mixture can be decided by considering the biological characteristics of the species, the sowing standard in a net sown area and quality of the seeds.

The sowing standard for each species in a mixture can be calculated by the following formula:

$$W = \frac{S \times P}{U}$$

where: W - is the weighted volume of the given species in the mixture (kg),

- S - the standard for the given species in net sown area (kg),
- P – level of participation of a given species in the mixture (%),
- U – usefulness of the seeds (%).

An example of calculation of the sowing standard for primary and secondary sowing is presented in the table below.

Table 3. An example of calculation of the sowing standard for participation of species in a mixture

1	2	3	4	5
Comprising species	**Participation in the mixture (%)**	**Sowing standard in the area net sown (kg)**	**Useability of seeds /U/ (%)**	**Weighted volume of seeds in a mixture for 1ha (kg) (3 x 2) : 5**
1. Festuka pratensis Huds.	25,0	37,5	100	(37,5x25,0):100=9,37
2. Dactylis glomerata L.	15,0	17,5	100	(17,5x15,0):100=2,62
3. Phleum pretense L.	25,0	18,0	100	(18,0x25,0):100=4,5
4. Trifolium pratense L.	20,0	27,0	95	(27,0x20,0):95=5,68
5. Trifolium hybridum L.	15,0	15,0	95	(15,0x15,0):95=2,36
Total	100			24,53

Note: The usefulness of seeds for sowing (U) depends on the purity (clean from debris and unnecessary particles) and the germination capacity (vitality). They are calculated as follows:

U = purity % x germination capacity % / 100.

According to the example on the table, it becomes clear that the sum of calculated standards for the sowing of the species envisaged in the mixture will become the standard of sowing of the combined mixture per 1 hectare of land.

The species composition and the sowing standard for sown area of perennial legumes and cereals, used for creating a grass mixture are presented in Annex 1.

2.4 The system of fundamental improvements of degraded grazing lands

The system of fundamental improvements of grazing lands is a complex of agrotechnical and hydromelliorative measures. One of the measures is plowing that destroys the vegetation and the turf layer of the degraded grazing land, in order to establish new vegetative cover by artificial sowing.

Fundamental improvements are performed on severely degraded pastures and grasslands, or on newly cultivated lands, where superficial improvement measures are not enough to increase the productivity of the grazing land.

The following are subject to fundamental improvements:

- aged, deteriorated, moss covered meadows and pastures,
- marshes and wetlands, after the improvement of the water regime,
- deforested and deshrubbed areas,
- areas where cereals and legumes are in minority (less than 10-15%), and the deteriorated grazing lands,
- meadows full of weeds, harmful and toxic plants.

Because of vertical zoning and steepness of the landscape in the administrative territory of Armenia, natural grazing lands occupy the steep slopes and plains of mountain gorges of various landscape zones. There are severely degraded areas on certain grazing lands, and implementation of superficial improvement measures may not be effective there. Increasing productivity and effectiveness indicators of these grazing lands is possible through implementation of fundamental improvement measures. It is

worth noting that organization and implementation of fundamental improvement measures on severely degraded grazing lands must be performed in primary consideration of the landscape conditions and the depth (width) of the turf layer. Fundamental improvements are permissible on flat slopes or slopes with 150 steepness only, where the turf layer is over 15–20cm thick. Otherwise, the destruction of turf layer by plowing, before the development of the new one (by artificial sowing) may contribute to erosion on such lands.

Fundamental improvements need analyses of soils, vegetation and hydrotechnical conditions of the area, implementation of meliorative and hydrotechnical works, cultivation and sowing with grass mixtures.

During the fundamental improvements, before the plowing of the turf layer, preparatory, agrotechnical works must be carried out to increase the useful surface and improve the appearance of the area.

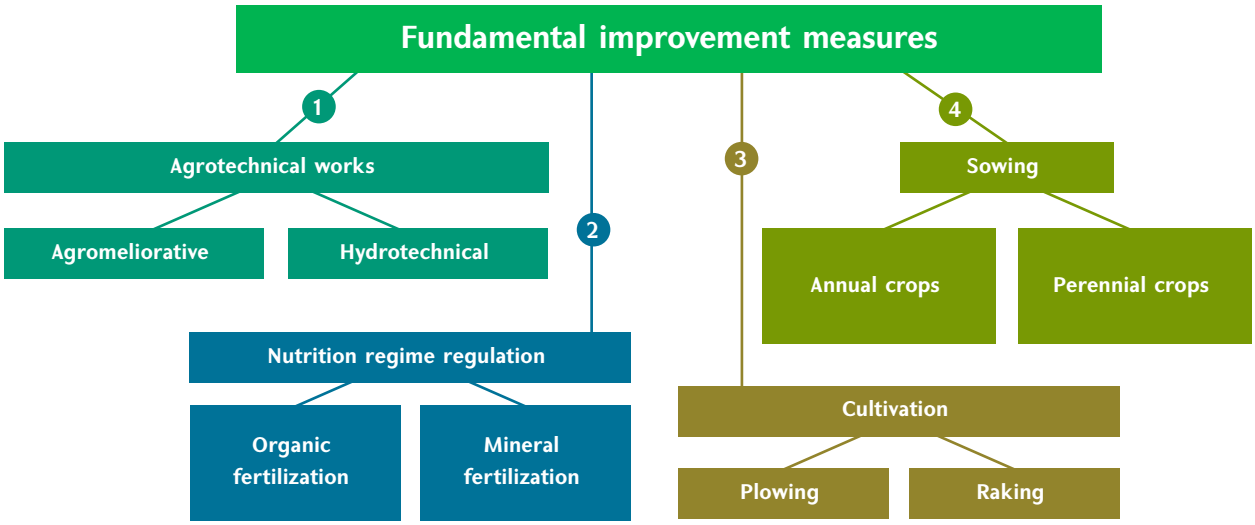


Figure 30: Fundamental improvement measures

Among the agromeliorative measures the following are of significance:

- stone collection,
- elimination of shrubs and dry trenches,
- flattening.

Such preparatory measures create sufficient conditions for establishing productive grazing lands with artificial sowing or self-seeding.

If necessary, hydrotechnical measures for regulation of the water regime may be implemented, depending on the conditions of the land, specifically on concaves with wetlands (marshes and azonal sections), as well as building (digging) of open drainage systems for reduction of spare humidity, and if the groundwater table is high then both open and close drainage systems may be required.

After the implementation of preparatory (agrotechnical, hydrotechnical) works in the area preliminary soil cultivation works must be performed. The implementation and the time period depend on the landscape, the climate conditions and the richness of the turf layer.

Preliminary soil cultivation: in order to create highly productive sown grazing lands (pastures and grasslands) by implementing fundamental improvements, it is necessary to carry out plowing on permissible depth (depending on the thickness of the turf layer), which will destroy the existing vegetative cover and the turf layer. Before the plowing it is necessary to fertilize the land by organic and (manure) and mineral (P, K) fertilizers. The plowing may be performed in spring, summer and fall, depending on the natural conditions and the landscape zone. On plains, areas with shallow turf layer, it is more effective to carry out the plowing in fall. In the following year, in spring, it may be necessary

to loosen 8–10cm of the upper soil layer by wheel rakes and ordinary rakes, and only then sowing by grass mixture has to be carried out.

It is possible to perform main and precultivation works and sowing on such lands also in spring and in summer.

Cultivation and sowing works on slopes up to 150 in average must be carried out in the same year. It is strictly prohibited to leave the plowed area without sowing till the next spring, as erosion will be inevitable. That is why sowing with grass mixture on slight slopes after plowing through the turf layer in spring is organized for the purpose of fast restoration of meadows.

Figure 31: Grass mixture

Fast restoration of meadows is the separate or mixed sowing of perennial plants on lands for fundamental improvements, immediately after complex preliminary (agrotechnical, meliorative, cultivation) works. Fast meadow establishment can be performed on all soils, all landscape zones and in all climatic conditions. It may be more effective to carry out such a restoration in valleys with arid and moderately humid climates, on grazing lands with water flows, sandy and rubble soils.

Works on fast restoration of meadows on steep slopes must be performed in spring. Immediately after the cultivation a mixture of perennial special must be sowed on the land, covered by annual plants (barley, oats and vetch). The importance of such a cover is that perennials grow slower in the sowing year, and the annuals grow faster. The latter create a vegetative cover in a short period of time and prevent the possible erosion. In the following years, the perennials grow over and establish a dense cover and a turf layer, hence excluding the possibility of erosion completely.

The establishment of artificial grazing lands by fundamental measures is performed by sowing mixtures of annual and perennial plants, which supposes the development of a system of rotational sowing by priority. During the fundamental improvements 3 types of rotational sowing techniques are applied:

- forage,
- soil protection,
- biomeliorative.

In order to restore degraded grazing lands and increase their economic value meadow sowing rotation is applied in improved lands by planting annual and perennial species in sequence. Rotational meadow restoration takes place in two phases: field and meadow. In the field phase mostly annual plants are used, in order to improve the qualitative composition of the soil. After some time (2–3 years) the same area is used to sow mixtures of legumes and cereals.

Soil protection and anti-erosion cultivation measures during the artificial improvements are of mostly environmental significance. Their main purpose is to increase the economic effectiveness of the improved area and prevent the occurrence and development of erosion phenomena on steep slopes, by implementing fast meadow restoration.

Biomelliorative rotational sowing, during the fundamental improvements, is implemented for the purpose of restoring salinated and alkaline lands and establishing croplands of fodder. Gypsum is used together with organic fertilizers during plowing in fall on such lands. As a rule, salt resistant legumes are used in mixtures sown on such lands. After planting these legumes the area becomes more shadowed, reducing the intensity of evapotranspiration from soil and the movement of salt towards the surface. With time, after the death and decomposition of roots of sown legumes, tubular formations occur in soil, due to which the accummulated salts on the surface of the soil after the irrigation are dissolved and penetrate the deeper layers.

3. The importance of availability of seeds of local perennial plants during the improvement measures and the process of seed production in the RA.

Availability of seeds of perennial cereals and legumes is of primary importance for improvement of natural grazing lands and establishment of sown agricultural lands.

The seeds of grasslan-pasture plants are mostly obtained through reproduction of selected vareties and wild edible plants (cereals and legumes). Significant efforts were invested in restoration and improvement of degraded natural grazing lands (grasslands and pastures) in the framework of agricultural and environmental projects implemented in Armenia by various international and local organizations. The seeds of perennial plants (in mixtures) needed for secondary sowing for enriching the vegetative cover during the improvement measures implemented on degraded natural grazing lands are mostly imported from foreign markets, as there is no local production of such mixtures in the RA. The issue persists, because various public and private seed production facilities, as well as small, medium and large farms in the country currently mostly produce seeds of annual crops to satisfy the demands of food and fodder. There is production of seeds of perennials in limited quantity, mostly alfalfa and seinfoin, which are mostly used to establish sown croplands and grasslands. In many cases, public programs funded the import of alfalfa and seinfoin seeds, in order to satisfy the local demands for seeds. As a rule, when the imported seeds of plants that had grown in other climatic conditions were sown in different landscape zones the results were not satisfactory, as the established vegetative cover regressed, because it could not adapt to local conditions.

When importing seeds and carrying out secondary sowing, special attention should be paid to the species that may well adapt to a given landscape zone.

In economic terms, the import of seeds of prennials is quite costly.

In consideration of the natural conditions and the diversity of species of edible plants in various landscape zones of the Republic of Armenia, it is also necessary to ensure the growing and production of seeds of selected grassland-pasture plant species and wild species in various public and private seed production facilities, because grasslands and pastures that can be established by the use of locally produced and highly demanded seeds of plants will guarantee higher productivity and efficiency because of high adaptability of populations of those species to the local conditions. Currently, there are quite a few selective varieties of perennial cereals and legumes (alfalfa, seinfoin, clover, ryegrasses) in the state registry of selection achievements of Armenia, however, seeds are produced only for alfalfa and seinfoin and only by individual farmers.

The strategic programs on development of agriculture in Armenia, currently, pay a lot of attention to establishment and development of seed production of (annual and perennial) plants grown for food and fodder purposes, in order to satisfy the local demands. The estblishment and development of seed production of perennial plant varieties and using the seeds of local varieties is also relevant and may have perspectives of development.

4. Annexes

Annex 1

4.1. Standard of sowing perennial plants on a net sown area with 100% of usefulness, and the main biological characteristics of such plants

Plant	Net sown standard kg/ha	Biological characteristics			Longevity in the grass mixture
		Tillering type	Foliation on the stem	Year of maximum yield	
1	2	3	4	5	6
Trifolium pretense L.	12–18	Shrubs	High	2	Low
Trifolium repens L.	8–10	Shrubs	Low	3–4	High
Trifolium hybridum L.	8–10	Shrubs	High	2	High
Medicago sativa L.	18–20	Shrubs	High	2–3	Medium
Medicago falcata L.	12–16	Shrubs	High	3–4	High
Onobrychis viciifolia Scop.	130–150	Shrubs	High	2	Medium
Lotus corniculatus L.	12–14	Shrubs	High	2–3	Medium to High
Lolium perenne L.	25–30	Bunch	Medium	2	Various
Arhenatherum elatius L.	30–35	Bunch	High	2–3	Low
Lolium multiflorum Lam.	20–25	Bunch	High	2	Low
Elymus trachycaulon	20–25	Bunch	High	2–3	Medium
Agropyrum repens L.	25–30	Rhizomatous	High	2–3	High
Festuca pratensis Huds.	20–25	Bunch	High	2–3	Medium to High
Festuca rubra L.	18	Rhizomatous	Low	3–4	High
Phleum pretense L.	10–12	Bunch	High	2–3	Medium
Dactylis glomerata L.	18–20	Bunch	High	2–3	Medium to High
Alopecurus pratensis L.	12–16	Rhizomatous	High	2–3	High
Bromus inermis Leyss.	25–30	Rhizomatous	High	2–3	Medium to High
Poa pratensis L.	10–12	Rhizomatous	Low	3–4	High
Agrostis stolonifera L.	8–9	Rhizomatous	Low	3–4	High
Agropiron crisitatum L.	16–18	Bunch	Medium	3–4	High

Note: Data on the sowing standard of perennial plants and their biological characteristics in Annex 1, are presented in accordance with N.G. Andreyev (Pasture Studies), Yerevan, 1985.

Annex 2

4.1. Examples of methodical implementation of the guidelines

Description

In order to explain the effectiveness of methodology of the developed guidelines, as well as the efficiency of recommended technological measures for improvement, a joint intiative of the German International Cooperation Agency (GIZ) and the Strategic Development Agency NGO, implemented by the Integrated Biodiversity Management in the South-Caucasus Project in three marzes (Syunik, Aragatsotn and Shirak) and 12 rural settlements of 6 pilot communities of Armenia considered experimental measures on improvement of degraded pasture and capacity building for involved communities, based on the methodology presented in the guidelines. Below are the preliminary results of pilot measures, implemented in the administrative territories of three different rural communities (Goraik, Geghadzor and Berdashen) of three different marzes (Syunik, Aragatsotn and Shirak).

Degraded pastures were selected in the administrative territories of three different rural communities of different marzes, where field assessments were carried out for the purposes of identifying the environmental and economic conditions of the area and implementing restoration and improvement measures. The field assessments were carried out in accordance with the methodology of **«Summer pasture monitoring manual, Armenia»**. Baseline indicators, established by the economic and ecological assessment of the three selected areas, are presented in Tables 1 and 2.

Table 4. Baseline characteristics of conditions of selected pilot pasture lands

Community	Settlement	Pasture	Area (ha)	Vegetation cover (%)	Cereals and legumes (%)	Mixed grasses (%)	
						Total	Of which low quality weeds
Goraik	**Goraik**	N-4	3.0	58	41	59	15
Arpi	**Berdashen**	Horti Arot	1.5	66	53	47	17
Tsaghkahovit	**Geghadzor**	Gogedosh	1.5	64	40	60	16

According to the analysis of data obtained through field assessments (Table 1), the average vegetative cover in the target communities comprised 58-66%, which is quite a low indicator that may significantly impact the indicators of productivity (fertility) of the vegetative cover. The quantity of high quality edible plants (cereals and legumes) in the vegetative cover is also very low (40-53%), whereas the composition of mixed grasses is incomparably higher (47-60%). The quantity of harmful and low quality species is also high among the latter (15-17%).

Analysis and assessment of indicators identified through field evaluation found out that degradation on selected lands is reaching medium and high levels of risk (Table 2).

Table 5. Characteristics of ecological and economic conditions of pilot pastures

Community	Settlement	Pilot areas / ha	PD	EV	PCI	Permissible load of a pasture
						Provisional heads of cattle/ha
Goraik	**Goraik**	3.0	0	2.5	2.5	0.4
Arpi	**Berdashen**	1.5	2.5	2.5	5.0	0.6
Tsaghkahovit	**Geghadzor**	1.5	2.5	0	2.5	0.4

Note: Red – high risk, Yellow – medium risk


Geghadzor


Goraik


Berdashen

- Development of erosion through linear degradation,
- 2. Destruction of the vegetative cover because of dry trenches established through trampling,
- 3. Destruction of vegetation through overgrazing, deterioration.

Development of improvement projects

According to the nature and levels of degradation on the selected pasture plots (selected pilot pastures), the methodology described in the guidelines was used to elaborate complex programs of agrotechnical–restoration measures by superficial improvements for every selected pilot area in all the target settlements of the mentioned communities. Various improvement measures were elaborated for three pilot areas with difrerent levels of degradation:

1. The following was envisaged for the pilot area of Goraik:

- Agrotechnical measures (stone collection, elimination of shrubs and trenches, flattening),
- Improvement of aeration regime and protection of the turf layer (loosening and raking of the turf layer),
- Organic fertilization (matured manure),
- Mineral fertilization (nitrogen, phosphorus and potassium),
- Enriching the vegetative cover by secondary sowing (using mixtures of legumes and cereals),
- Installation of an electric fence.

2. The following was envisaged for the pilot area of Geghadzor:

- Agrotechnical measures (stone collection, elimination of shrubs and trenches, flattening),
- Building anti-erpsion estuaries,
- Improvement of aeration regime (loosening and raking of the turf layer),
- Mineral fertilization (nitrogen, phosphorus and potassium),
- Enriching the vegetative cover by secondary sowing (using mixtures of legumes and cereals),
- Installation of an electric fence.

3. The following was envisaged for the pilot area of Berdashen:

- Organic fertilization (matured manure),
- Improvement of aeration regime (loosening and raking of the turf layer),
- Enriching the vegetative cover by secondary sowing (using mixtures of legumes and cereals),
- Installation of an electric fence.

Implementation of improvement projects

Restoration and improvement measures were implemented in fall of 2017 and spring of 2018. In fall 2017 agrotechnical measures (stone collection, flattening, eliminatio of shrubs and dry trenches) and main fertilization by manure and minerals (phosphorus and potassium) were implemented on selected pilot areas in the vicinity of Goraik rural settlement. Only organic fertlization was carried out on selected pilot

areas in the vicinity of Berdashen rural settlement. The planned improvement measures on selected pilot areas in the vicinity of Geghadzor were implemented in spring of 2018, when the implementation of main improvements underwent the second phase in the pilot areas of Goraik and Berdashen. The results of implemented improvement measures and the calculated indicators are presented in Tables 3, 4, and 5.

Table 6. Chracteristics of conditions of the selected pastures (Comparison of baseline and final data)

Community	Settlement	Pasture	Registered results	Vegetative cover (%)	Cereals and legumes (%)	Mixed grasses (%)	
						Total	Of which, low quality weeds
Goraik	Goraik	N-4	Baseline	58	41	59	15
			Final	97	74	26	6
Arpi	Berdashen	Horti Arot	Baseline	66	53	47	17
			Final	96	72	28	3
Tsaghkahovit	Geghadzor	Gogedosh	Baseline	64	40	60	16
			Final	93	72	28	3

Note: Baseline – indicators identified before the measures,
Final – results after the finally implemented measures

Analysis of data obtained through field assessments in the pilot areas where improvement measures were implemented found out that there were significant alterations in total vegetation and the corelation of botanical coexistencies in vegetative covers of the pastures. The comparison of indicators of baseline (before the improvement) and final (after the improvement) measures found that average vegetation cover in various areas increased by 29-39% compared to the baseline indicators (minimum and maximum), whereas on the improved areas it comprised 93-97% (minimum and maximum). See Table 3.

The results of analysis of comparison of baseline and final indicators in 3 pilot areas (Table 3) by communities and settlements of communities are presented in Table 4.

Table 7. Comparative analysis of baseline and final results of assessment of conditions of selected areas

Community	Settlement	Pasture	Increase of the vegetative cover (%)	Increase of cereals and legumes (%)	Reduction of mixed grasses (%)	
					Total	Of which low quality weeds
Goraik	Goraik	N-4	67	81	56	60
Arpi	Berdashen	Horti Arot	45	36	59	82
Tsaghkahovit	Geghadzor	Gogedosh	45	80	53	81

Based on the preliminary results of comparison of baseline (before the restoration) and final (after the restoration) measures, we may irrevocably state that implemented restoration measures have ensured the complete restoration of degraded pasture lands, which is expressed by increase of vegetation and higher density of plants growing on deteriorated and depleted sections of grazing lands, but

also by increase of quantity of high quality edible plants and by unprecedented reduction of mixed grasses, and especially harmful, non-edible species. In result of all these actions degradation and erosion related phenomena have been significantly reduced or almost completely eliminated from the improved areas. They have also contributed to double and even higher increase of pasture productivity and quality indicators, even when species planted through secondary sowing have not yet occupied a significant place on the total vegetative cover, because perennial plants do not demonstrate significant growth in the first year of sowing or secondary sowing, but only in the year following the one with secondary sowing. The results of baseline monitoring (before the improvements) and final (after improvements) monitoring of ecological and economic conditons of pastures under improvement measures are presented in Table 5.

Table 8. Baseline and final results of monitoring of ecological and economic conditions of the selected areas

Community	Settlement	Recorded results	PD	EV	PCI	Permissible load of the pasture Provisional heads of cattle/ha
Goraik	Goraik	Baseline	0	2.5	2.5	0.4
		Final	5	5	10	1.0
Arpi	Berdashen	Baseline	2.5	2.5	5.0	0.6
		Final	5	5	10	1.0
Tsaghkahovit	Geghadzor	Baseline	2.5	0	2.5	0.4
		Final	5	5	10	1.0

Note: Red – high risk,
Yellow – average risk
Green – low risk

According to the analysis of evaluation results of restoration measures implemented in selected areas, it becomes clear that

- degradation has been significantly reduced,
- the deteriorated areas have almost completely been improved (covered by vegetation),
- the productivity and the quality of collected harvest have been twice increased on improved lands.

The comparison of monitoring results shows that even in areas with high degradation (Goraik), implementation of improvement measures may completely eliminate degradation in the first year.

The calculation of empirical values obtained through application of ԱԴՑ and ԷՀՑ assessment indicators from improved lands, shows that maximum results were achieved on improved lands, in which case the calculated PCI value ensures the maximum standard of PLP (1 Provisional heads of cattle/ha).



Geghadzor Goraik Berdashen

Figure 32: Selected pilot degraded pastures before improvements



Geghadzor Goraik Berdashen

Figure 33: Pilot degraded pastures after improvements

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Published by

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of German Federal Ministry for Economic Cooperation and Development (BMZ).

Registered offices

Bonn and Eschborn, Germany

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May, 2020

The opinion and conclusions expressed in this publication are those of the author and do not necessarily coincide with the views of GIZ, BMZ or its respective Government.

Ministry of Territorial Administration and Infrastructure of the Republic of Armenia

Ministry of Economy of the Republic of Armenia

Գերմանական համագործակցություն
DEUTSCHE ZUSAMMENARBEIT

Implemented by:
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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