AUA ACOPIAN CENTER for the ENVIRONMENT

UNIVERSITÄT HOHENHEIM

Project report

Expanding Plant Species in Armenia

A case study from Geghadzor and Kuchak in the Aragatsotn marz

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30th of January 2020

This project is a part of the DAAD-funded collaboration, GAtES (German-Armenian Network on the Advancement of Public Participation GIS for Ecosystem Services as a Means for Biodiversity Conservation and Sustainable Development), between the University of Hohenheim (UHOH) and the American University of Armenia's (AUA) Acopian Center for the Environment.

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List of abbreviations

ACE	Acopian Center for the Environment
ACB	Argument Consulting Bureau LLC
ARMSTAT	Statistical Committee of the Republic of Armenia
AUA	American University of Armenia
BFH	Bern University of Applied Sciences
BSC	Business Support Center
CARMAC	Community Agricultural Resource Management and Competitiveness
CBD	Convention on Biological Diversity
DAAD	German Academic Exchange Service
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Statistics of the Food and Agriculture Organization of the United Nations
GAtES	German-Armenian Network on the Advancement of Public Participation GIS for Ecosystem Services as a Means for Biodiversity Conservation and Sustainable Development
GIZ	German Society for International Cooperation
IBiS	Integrated Biodiversity Management South Caucasus
MoA	Ministry of Agriculture
MoNP	Ministry of Nature Protection
MoTAD	Ministry of Territorial Administration and Development
OSFA	Open Society Foundations Armenia
RA	Republic of Armenia
UHOH	University of Hohenheim
USAID	United States Agency International Development
USDA	United States Department of Agriculture
PPGIS	Public Participation Geographic Information System
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEVOC	International Center for Technical and Vocational Education and Training
WB	World Bank

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1. Introduction

Biodiversity and ecosystems offer a wide range of provisioning, regulating, cultural and supporting services which are of utmost importance for the well-being of humankind (GIZ 2018). However, in recent decades, human activities contributed to the steady degradation and transformation of ecosystems and thereby endanger biodiversity on a global scale (Fayvush and Tamanyan 2014; GIZ 2018). The same phenomenon can also be observed in Armenia – a landlocked, mountainous country in the South Caucasus which is known for its unique biodiversity and diverse ecosystems which developed from highly diverse landscapes and climatic conditions (MoA, 2008; Fayvush & Tamanyan, 2014; Vardhanyan et al., 2014). Hosting several wild relatives of globally cultivated plants like barley, rye and wheat, Armenia furthermore holds an crucial role in agrobiodiversity conservation (MoA 2008; Vardhanyan et al. 2014).

Approximately 60-65% of the country's territory (ca. 2-2.1 million ha) are suitable for agricultural production from which around 50% (1.05-1.2 million ha) comprise pastures and grasslands (MoA 2008; Mezhunts and Navasardyan 2014; Vardhanyan et al. 2014; Avagyan 2018; RA 2019; FAO 2020). Armenia's large natural fodder areas are not only fundamental for livestock husbandry, but also are a valuable resource of biodiversity and its conservation (Tovmasyan 2015a). Due to the high availability of pastures and grasslands, livestock husbandry is one of Armenia's oldest and most important agricultural branches (Tovmasyan 2015a; Tovmasyan 2015b; RA 2019). Although livestock numbers decreased significantly since the breakdown of the Soviet Union in 1991, 57% of Armenia's pastures and natural grasslands are considered as degraded as a result of unregulated and unsustainable grazing management (Fayvush and Tamanyan 2014; Vardhanyan et al. 2014; GIZ 2018).

One major consequence of the mismanagement of pastures is the ongoing expansion of native plant species into valuable grasslands (Fayvush and Tamanyan 2014; Vardhanyan et al. 2014; RA 2019). According to the definition, so-called expansive plant species are part of a country's native vegetation but have a highly competitive ability to spread into new, often disturbed habitats, for instance degraded pastures (Prach and Wade 1992; Pyšek et al. 2004).

One of the most concerning expansive plant species in northern Armenia is *Astragalus galegiformis* which has excessively penetrated into natural ecosystems and pasture land during the past 15 years, especially in Aragatsotn and Shirak marzes (Fayvush and Tamanyan 2014; Fayvush et al. 2015).

These regions are known to have heavily suffered from overgrazing and grassland degradation in the last decades (Fayvush and Tamanyan 2014; GIZ 2018). According to Aleksanyan and Fayvush (2016), about 15'000 ha of pastures and natural grasslands are already infested by *Astragalus galegiformis* and it is expected to further spread all over in North Armenia. Suppressing other valuable native plant species and decreasing natural fodder-producing areas for livestock, expansive plant species are threatening Armenia's rich biodiversity which is crucial for the well-functioning of agroecosystems and the provision of ecosystem services (Fayvush and Tamanyan 2014).

As agriculture is an economic key sector of Armenia (Urutyan and Thalmann 2011; WB 2012; Melkonyan 2015; Poleshkina and Peplozyan 2016), it is important that available agricultural land and its biodiversity are maintained in good condition to ensure employment, alleviate poverty and support the country's economic development.

2. State of research

In general, it can be stated that a wide range of projects has been undertaken in Armenia in the area of pasture management, pasture rehabilitation and improvement of livestock husbandry and productivity in the past decades. One of the most important agencies which has been active in Armenia since the 1990s is the German Society for International Cooperation (GIZ). From 2015-2019, they conducted the supranational project «Integrated Biodiversity Management South Caucasus» (IBiS) in Armenia, Georgia and Azerbaijan (IBiS 2018). In the frame of IBiS, the GIZ implemented rehabilitation measures in 15 communities of Syunik, Shirak and Aragatsotn marzes (ibid.). Furthermore, they developed a methodology to assess the erosion sensitivity of pastures and elaborated different manuals regarding pasture management and monitoring (ibid.).
Another important international actor to mention is the World Bank and their project «Community Agricultural Resources Management and Competitiveness» (CARMAC) whereas CARMAC I lasted from 2011-2016 and CARMAC II started in 2015 and is aimed to be finalised in May 2020.
Additional organisations working on pasture management and livestock husbandry in the rural areas of Armenia are the Swiss Agency for Development and Cooperation as well as the non-governmental organisation Strategic Development Agency (SDA).
Nevertheless, information on project outcomes is relatively scarce because either there were no reports published or a lot of them are only available in Armenian.

In the following subchapters, different important aspects of livestock husbandry and pasture management are described. As the student research project was conducted in the Aragatsotn marz, the focus will be on this province.

2.1. Geghadzor and Kuchak in the Aragatsotn marz

The Aragatsotn marz is one of 12 administrative provinces in Armenia and borders Lori and Shirak marzes in the north, Armavir and Yerevan marzes in the south-east, Kotayq marz in the east and and Turkey in the west as shown in **Figure 1** (Avetisyan 2010). With 2'756 km^2, the Aragatsotn marz covers about 9.3% Armenia's territory of 29'800 km^2 (ibid.). In total, there were 125'400 people living in 114 communities in Aragatsotn marz in 2018, from which 78% people life in rural areas (Avetisyan 2010; ARMSTAT 2019). The population's main income generating activities are agricutlure, mainly livestock husbandry, and industry which comprises food processing, mining operations and productin of precious items (ibid.).
Geghadzor and Kuchak are two of the rural communities in the Aragatsotn marz and have been part in the World Bank's CARMAC project and the IBiS project by GIZ. Therefore, the next sections will give a brief description of both communities.

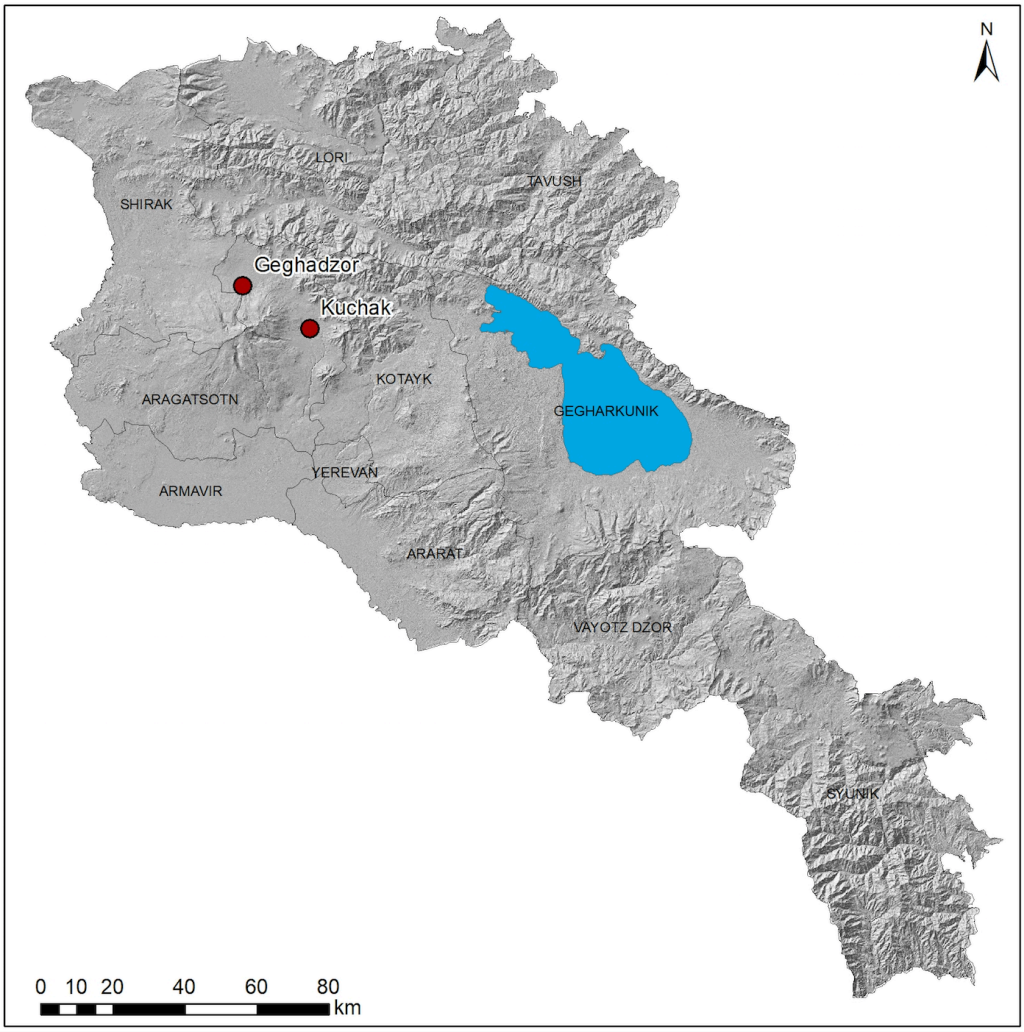

Figure 1: Administrative provinces of the Republic of Armenia

Both communities are found in the mountainous area of the Aragatsotn massif (see **Figure 1**). Geghadzor community is located at 2'190 m asl in the north-west of Aragatsotn marz, close to the border of Shirak marz (ACB 2014). Kuchak is found at 1'850 m asl on the north-eastern slope of the Aragats massif (BSC 2017). Whereas the distance to the capital city Yerevan is 75 km for Geghadzor, it is only 18 km for Kuchak (ACB 2014; BSC 2017).
Annual precipitation in both communities is on average 450-600 mm (ibid.). Whereas winters are characteristically long and cold with average temperatures between -8°C and -6°C in January, summers are relatively humid and mild with averge temperatures between 16°C and 18°C in July (ibid.).

In 2018, there were 2'276 people living in Kuchak and 1'189 in Geghadzor (MoTAD 2019a; MoTAD 2019b). According to numbers from 2014, around 50% of the population in Geghadzor were employed, from which more 91% were working in agricultural production (ACB 2014). In Kuchak, it can only be stated that around 31.6% of income is attributed to the sale of livestock-derived products and 13.4% to the sale of cereals and potatoes (Akhbalyans and Mambreyan 2015). Due to the limited employment oppurtunities, seasonal labour migration is high in both communities (ACB 2014; BSC 2017).

2.2. Livestock husbandry in Armenia

Animal husbandry is the second most important agricultural sector after crop production and produces approximately 40% of the total agricultural gross production in Armenia (Avetisyan 2010; MoA 2020). Breeding of cattle, sheep and goat, poultry and pig build the pillar of livestock husbandry (ibid.). After the collapse of the Soviet Union in 1991, animal stocks, especially of chicken, sheep and pig, decreased drastically, before they stabilised and eventually started to increase at the end of the 1990s as shown in **Figure 2** (Avetisyan 2010; FAOSTAT 2020). In recent years, particularly sheep and cattle stocks began to decline again (ibid.).

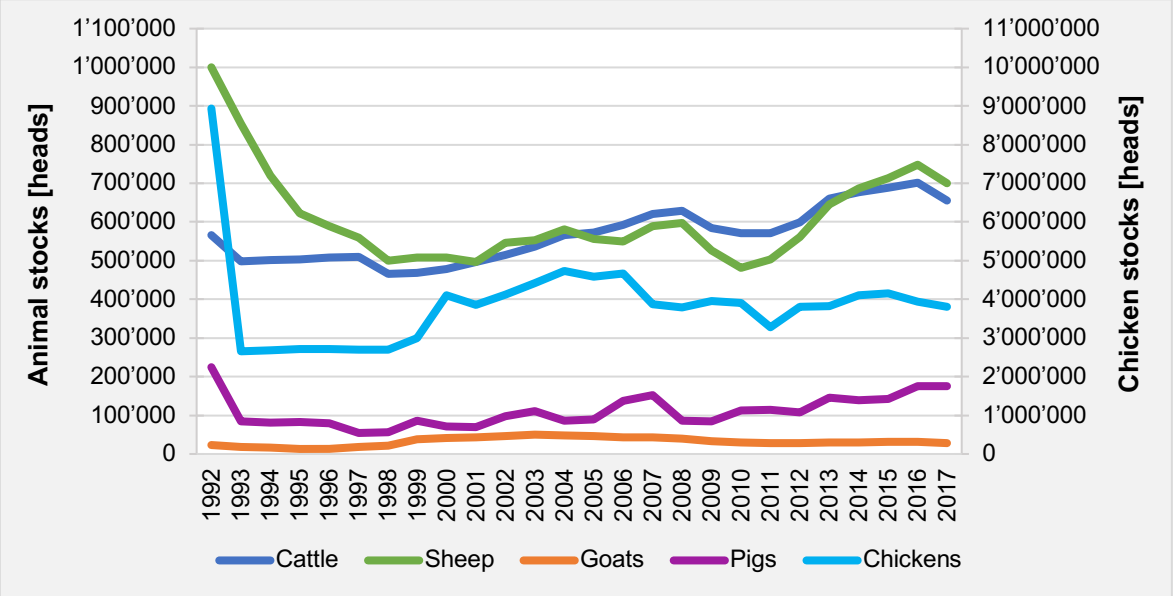

Figure 2: Development of cattle, sheep, goats and pig stocks [heads] and chicken stocks* [heads] in Armenia from 1992-2017 (source: adapted from FAOSTAT 2020)).
***Note:** Chicken stocks are displayed on the secondary axis on the right side.

Considering the vast pasture lands of Armenia, ruminants are dominating the livestock sector. Whereas sheep breeding is the traditional form of livestock husbandry in Armenia, cattle breeding is the most developed livestock branch (Avetisyan 2010; MoA 2019). Regarding small ruminants, goat breeding is traditionally of minor importance because sheep not only deliver milk and meat, but also wool. However, nowadays wool is only a by-product of sheep breeding (Bayer 2012).

According to official data, the Aragatsotn marz produced 10.2% of meat, 12.1% of milk, 9.3% of eggs and 13.9% of the wool from the total production in Armenia in 2016 (BSC 2017). Although it is difficult to find reliable data regarding the development and current level of animal stocks on the community level, it can be confirmed that sheep and cattle are the main livestock species in Geghadzor and Kuchak (see **Table 1**). Compared to poultry production, pig husbandry still seems to be of lower importance.

Table 1: Animals stocks [heads] in Geghadzor (2014) and Kuchak (2016) (source: adapted from ACB 2014; BSC 2017).

Animal stocks [heads]	Geghadzor	Kuchak
Cattle	1'849	1'867
from which are dairy cows	*829*	*792*
Sheep	1'091	767
Goats	0	48
Pigs	65	58
Poultry	1'553	3'580
Beehives	87	134

In both communities, the main cattle breed is the Caucasian Grey breed, although in recent years more crossbreeding was done, for instance through artificial insemination with semen from Brown Swiss cattle (Madatyan 2011; CARMAC 2016; Bayers no date). For sheep husbandry, the Balbas sheep breed with semi-coarse wool is the major breed used (ibid.).

In Geghadzor, livestock husbandry is small-scale (see **Table 2**). From 285 households involved in cattle husbandry in 2011, 67% had only up to 5 cattle on their farm (Madatyan 2011). 85 farms were active in sheep/goat breeding from which 71% did not have more than 5 sheep or goats on their farm (ibid.). In Kuchak, livestock husbandry is rather of medium scale. In 2016, 267 household raised cattle, from which 49% had up to 5 and 33% between 6 and 10 animals per farm (see **Table 2**). Additional 62 households were involved in sheep/goat breeding from which 33% had 6-10 sheep or goats on their farm and 46% even 11-30 sheep/goats.

Table 2: Distribution of households [%] in Geghadzor (2011) and Kuchak (2016) according to the number of animals [heads] per farm for cattle and sheep/goats (source: adapted from Madatyan 2011; CARMAC 2016).

Animals [heads] per farm	Geghadzor		Kuchak	
	Cattle	Sheep/Goats	Cattle	Sheep/Goats
Up to 5	67%	71%	49%	16%
6-10	21%	23%	33%	33%
11-30	12%	6%	16%	46%
31 or more	0%	0%	2%	5%
Total	**100%**	**100%**	**100%**	**100%**

Besides the cultivation of forage crops, mostly alfalfa (*Medicago sativa*), sainfoin (*Onobrychis viciifoia*), fodder beet (*Beta vulgaris*) and maize (*Zea mays*), pastures and natural grasslands are the main feed resources for cattle and sheep (Avetisyan 2010; Vardhanyan et al. 2014). In some cases, farmers buy small amount of barley, wheat and oats, either in form of whole grains or in form as bran (Madatyan 2011; CARMAC 2016). Given the importance of pastures and grasslands, the following chapter will focus on the relevant landscape zones which are crucial for cattle and sheep breeding in the Aragatsotn marz.

2.3. Relevant landscape zones for livestock husbandry

Due to its mountainous nature, Armenia's landscapes are highly diverse regarding climate, soils, geological substrate, terrain and hydrology (Fayvush and Tamanyan 2014). In total, 7 major landscape zones can be differentiated: (semi-)deserts, (dry) steppes, forests and (sub-)alpine lands (ibid.).

Semi-deserts are found in the so-called lower mountain belt which ranges from 480-1200 m asl (ibid.). Steppes, shrub and meadow steppes as well as forests and thorny vegetation are

attributed to the middle and upper mountain belt which range from 1'200-1'800 m asl and 1'800-2'200 m asl, respectively (ibid.). The forest belt generally covers altitudes between 500 and 2'400 m asl (ibid.). Turf and meadows are the major landscape form of the subalpine (2'200-2'700 m asl) and alpine (2'700-4'000) belt (ibid.). Generally, meadows are defined as grassland areas which are used on the one hand for grazing of ruminant livestock and on the other hand for haymaking (Bayer 2012; Avagyan 2018). Therefore, meadows are sometimes also named as haylands. Pastures in turn are considered as grasslands, naturally grown or sown, which are exclusively used for grazing of ruminants (ibid.).

Mountain steppes and mountain meadow steppes as well as subalpine and alpine meadows which are covering 37% and 28%, respectively, of Armenia's territory are of special importance for livestock husbandry, especially grazing livestock (Chemonics International Inc. 2000). **Figure 3** shows that for Geghadzor mainly mountain meadow steppes, subalpine and alpine meadows are the most relevant landscape zones. For Kuchak, the same landscape zones are of relevance and additionally the mountain steppes. In the following sections, specific characteristics of these landscape zones will be described for the context of the Aragats massif in the Aragatsotn marz.

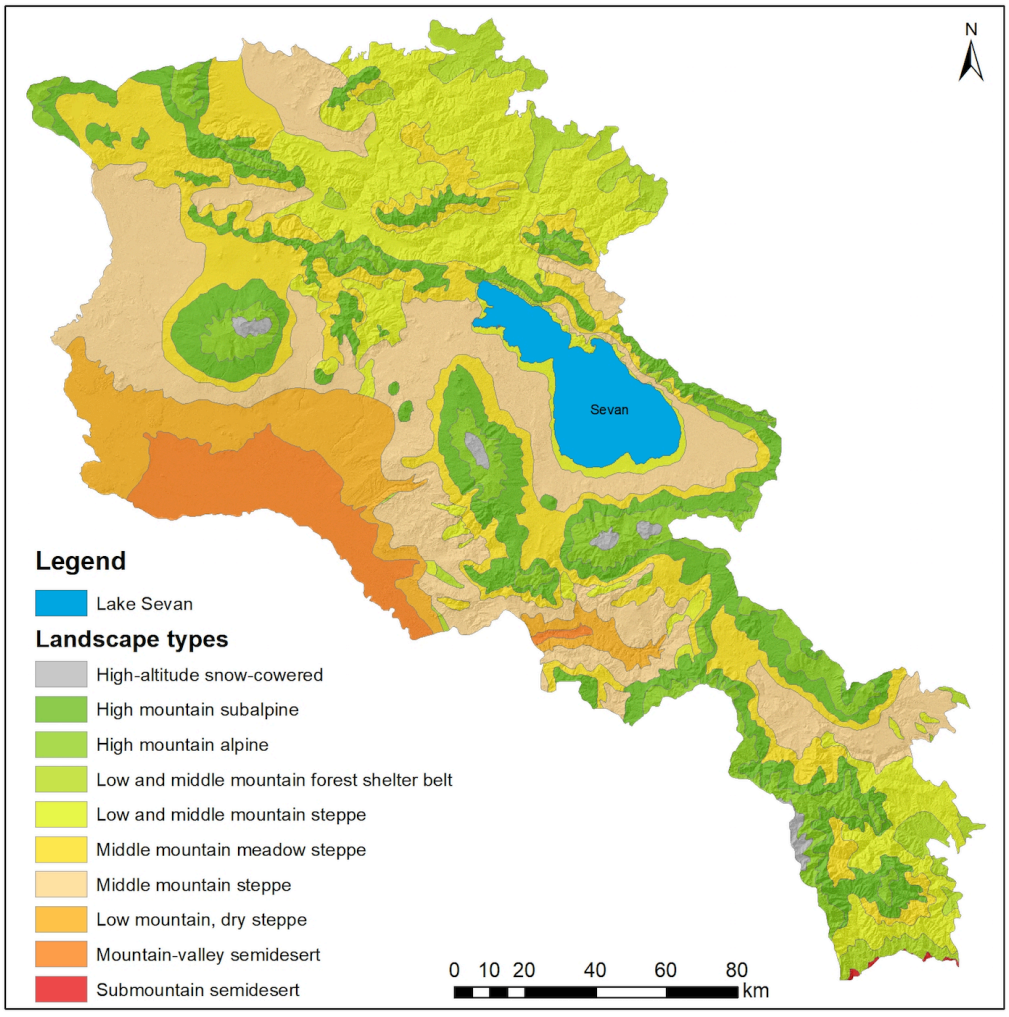

Figure 3: Landscape zones of the Republic of Armenia.

2.3.1. Mountain steppe

Ranging from 1'000 to 2'200 m asl, mountain steppes are characterised by low annual rainfalls of 450-600 mm, dry summers and cold winters with constant snow cover (Madatyan 2011; Bayer 2012; CARMAC 2016). Soils are usually of brown type and well humified, reaching humus contents of 6-11% in the topsoil layer (ibid.). Besides being used as pastures and to cultivate forage, mountain steppes are used to produce cereals and other irrigated and rainfed crops (Bayer 2012). Important plant species in mountain steppes are feather grass (*Stipa spp*.) and fescue (*Festuca sulcate*) (Chemonics International Inc. 2000). Shrub and thorny tragacanth (*Astragalus spp.*) steppes are an additional part of the vegetation of mountain steppes (Fayvush and Tamanyan 2014). Sometimes, mountain steppes are also named as the middle mountain belt (ibid.).

2.3.2. Mountain meadow steppe

The mountain meadow steppe belt, also upper mountain belt, covers altitudes of 1'500-1'800 m asl up to 2'100-2'400 m asl and is often described as the transition zone between mountain steppes and alpine meadows (Fayvush and Tamanyan 2014; Madatyan 2011; Bayer 2012). Annual precipitation varies between 600-700 mm (ibid.; CARMAC 2016). Compared to the mountain steppes, summer in the mountain meadow steppe is mild and winter is more humid (Madatyan 2011). The frost-free period lasts about 4-4.5 months (from mid-May until end of August), although hailstorms are quite frequent during these summer months (ibid.). The most widespread soil type in the mountain steppe belt are mountain black soils, mountain meadow steppe soils with high humus contents of 4-9% in the topsoil layer and a rooting depth up to 75 cm (CARMAC 2016). Especially in slopes with high inclination, the stoniness of soils is medium to high with parts of mother rock being visible in some areas (ibid.). Mountain meadow steppes are not only used for grazing and haymaking, but also serve for forage (annual and perennial), cereal and potato cultivation (Bayer 2012).

2.3.3. Subalpine meadow

The subalpine meadows are located in altitudes of 2'300-2'800 m asl, receiving relatively high annual rainfalls of 650-800 mm (Madatyan 2011; CARMAC 2016; Bayer 2012). Temperatures during summer are relatively cool, whereas winters are cold, long-lasting (4-5 months) and usually with permanent snow cover (CARMAC 2016). Turfy soils are widespread in the subalpine meadow belt, reaching rooting depths up to 50-60 cm (Madatyan 2011). Despite the short vegetation period of 3-3.5 months, subalpine meadows are considered as important feed resource for grazing livestock and for haymaking (Bayer 2012). 90-120 different species can be found in the lush vegetation of subalpine meadows from which the following genera are most widespread: *Agropyrum, Artemisia* (e.g. wormwood and tarragon*), Astragalus, Campanula (bellflowers), Carum, Cirsium (thistles), Festuca, Koeleria, Pedicularis, Phleum, Poa* (meadow grasses), *Prangos, Pyrethrum, Taraxacum (dandelions), Stipa (feather grasses) and Trifolium* (clover) (Madatyan 2011).
Other valuable plant species are alfalfa (*Medicago spp.*), marigold (*Tagetes spp.*), twiggy grass (*Panicum spp.*), bluebell (*Hyacinthoides non-scripta*), cornflower (*Centaurea cyanus*), veronica (*Veronica spp.*) and plantains (*Plantago spp.)* (Chemonics International Inc. 2000; Madatyan 2011; CARMAC 2016).

2.3.4. Alpine meadow

The alpine meadow belt extends from 2'700-3'500 m asl and is characterised by cool summers, very cold winters and high precipitations of 850-1000 mm per year (Fayvush and Tamanyan 2014; Madatyan 2011; Bayer 2012; CARMAC 2016). Due to the long and harsh winters (5-6 months) with constant snow cover which can last up to nine months, the brown and black turfy soils of alpine meadows are well humified but show a rather high level of stoniness (Chemonics International Inc. 2000; Madatyan 2011; CARMAC 2016). During the short vegetation period of 2-3 months, alpine meadows are used as summer pastures (Madatyan 2011; Bayer 2012). The most common plants are dandelions (*Taraxacum spp.*), bluebell (*Hyacinthoides non-scripta*), alpine bluegrass (*Poa alpina*), sedge (*Carex spp*.), sagebrush (*Artemisia tridentata*), fescue (*Festuca spp*.) and clover (*Trifolium spp.)* and others (Madatyan 2011).

2.4. Pasture management in the Aragatsotn marz

Table 3 summarises the agricultural land available in Kuchak and Geghadzor according to purpose. It is visible that the majority of agricultural land is pasture land which is 3'883 ha in Geghadzor and 1'555 ha in Kuchak (Madatyan 2011; CARMAC 2016). Nonetheless it is important to state that Geghadzor has a 2'500 ha area of special purpose land which is mainly used for military exercises by the Republic of Armenia and which are included in pasture lands (ACB 2014). Although ACB (2014) indicates that this land is not used for agricultural production, the land was included in the pasture management plan which was developed by the CARMAC project. If the special purpose area is not included, pasture lands cover in total 1'883 ha in Geghadzor (ibid.). However, **Table 3** further reveals that pasture area in Kuchak is more or less balanced between near-by community pastures and remote pasture lands. On the contrary, the vast majority of pastures in Geghadzor are located in remote areas.

Table 3: Agricultural land in Geghadzor (2014) and Kuchak (2016) according to use, indicated in hectares [ha] and relative shares [%] of total agricultural land (source: adapted from Madatyan 2011; CARMAC 2016).

Agricultural land	Geghadzor		Kuchak	
	ha	%	ha	%
Arable land	683	14.3	1'248	36.5
Hayland	107	2.2	154	4.5
Pastures	3'883	81.3	1'555	45.4
Near-by pastures	*790*	*16.5*	*794*	*23.2*
Remote pastures	*3'093*	*64.7*	*761*	*22.2*
Other land	107	2.2	464	13.6
Total	**4'780**	**100**	**3'421**	**100**

Overall, grazing period for sheep and cattle are different (Madatyan 2011; CARMCAC 2016). For cattle, grazing season usually starts in early May when the snow cover is melted, for sheep and goats it already begins in the beginning of April (ibid.). From May to mid-July (ca. 75 days) grazing livestock is brought to the mountain steppes and mountain meadow steppes (ibid.). Afterwards, cattle and sheep move to higher altitudes to the subalpine meadows where they only stay around 30 days as a part of the grassland is also used for haymaking (ibid.). Next, ruminants are grazing on alpine meadows approximately from mid-August to mid-October (ibid.). As soon as haymaking and crop harvesting are over, grazing livestock is brought back to lower elevations, i.e. mountain (meadow) steppes and and arable lands where cattle and sheep can graze on stubbles (ibid.). Normally, stubble grazing can last for about 2 months

(around October to November). Of course, the shifting of grazing livestock is always influenced by the specific weather conditions of each year.
As using remote pastures on an individual basis is no option for farmers due to the small livestock numbers they have, grazing livestock is divided into different herds of cattle and flocks of sheep and goats to ensure an effective and centralised pasture use during the grazing season (ACB 2014). Calves up to 8 months, lambs and kids (i.e. baby goats) are commonly not brought to pastures, but are kept and fed in stables (CARMAC 2016).

In the frame of the World Bank's CARMAC project, in both communities there was a pasture user cooperation founded and a pasture management plan was implemented to coordinate grazing more efficiently and thereby improve overall pasture use (Madatyan 2011; CARMCAC 2016). This pasture management plan was created considering pasture yield, pasture location, landscape zone, distance from community and number of livestock (ibid.).

2.5. Causes and consequences of pasture mismanagement

During the past decades, pastures and natural grassland in Armenia have been constantly deteriorating due to the mismanagement of grazing livestock by the rural population (Chemonics International Inc. 2000; MoNP 2009; Madatyan 2011; Fayvush and Tamanyan 2014; CARMAC 2016; RA 2019). Approximately 150'000 ha of pastures and hayfields have been abandoned in the past 60 years due to degradation (RA 2019). According to the RA (2019) and the MoNP (2009), the state of mountain steppes, mountain steppe meadows, subalpine and alpine meadows is alarming and it is assumed that damages of grassland ecosystem will soon be irreversible if degradation processes are not stopped in the near future.

2.5.1. Reasons for pasture mismanagement

The reasons for the unregulated and inadequate management of pastures are diverse. One crucial factor is poverty which was reported to affect 23.5% of Armenia's population in 2018 (Hergnyan 2019; Sahakian 2019). In Aragatsotn marz, on average 16.2% of the local people live below the poverty line (Hergnyan 2019). Thus, people often lack financial capital to invest into livestock husbandry and maintenance and improvement measures for pastures (MoNP 2009; Vardhanyan et al. 2014). Moreover, economic issues contribute to lacking and inadequate infrastructure which has negative impacts on livestock husbandry in several ways (Madatyan 2011; Vardhanyan et al. 2014; RA 2019).
Firstly, the poor condition of roads makes it difficult for farmers and shepherds to access remote pastures of the mountain steppe, subalpine and alpine meadow belts (Madatyan 2011; CARMAC 2016). Grazing livestock in Geghadzor and Kuchak has to walk on average 10-15 km per day to access the pastures, graze, drink and return (ACB 2014; BSC 2017). Due to the bad road conditions, this uses a lot of energy and subsequently has a negative impact on productivity of grazing livestock (ibid.).
Secondly, there is no or only deteriorated infrastructure in terms of watering points, animal stables and accommodation for shepherds available on remote pastures (ibid.; ACB 2014; Bayer 2012). Watering points are crucial for livestock productivity, because with if water intake is restricted, feed intake will decrease as well and productivity will decline, too (Bayer 2012). Furthermore, it is increasingly difficult to find shepherds who are willing to herd grazing livestock during the vegetation period under partly harsh conditions (Hayrapetyan 2019, personal communication).

Thirdly, the daily milking procedure is another reason why grazing livestock is preferably kept on close-by pastures (ACB 2014). Milk and other dairy products are an important contribution to the daily diets of rural population (ibid.). Furthermore, there is also no infrastructure available in remote areas which would allow milking the grazing livestock on remote pastures and cool and process the milk there as well.
Another important factor is education which is often more difficult to access for the population in rural areas and is also found to be of lower quality compared to education in urban areas (OSFA 2018). Although there is the National Agrarian State University in the capital Yerevan, there is no technical and vocational education training for agriculture available in rural areas (UNESCO-UNEVOC 2012, cited in Bynum Boley and Hammett 2013). As the rural population lacks the skills and knowledge to improve pasture management and sustain agriculture, people largely rely on traditional agricultural practices for crop production and livestock husbandry.

2.5.2. Soil erosion and decreasing pasture productivity

Whereas remote grazing sites and summer pastures suffer from degradation in form of undergrazing, pastures and meadows in vicinity of communities are often exposed to overgrazing (Madatyan 2011; Fayvush and Tamanyan 2014; Vardhanyan et al. 2014; Tovmasyan 2015a; CARMAC 2016; GIZ 2018; RA 2019). Steady trampling of pastures and uncontrolled grazing continuously decrease the vegetation cover whereas wind and water further contribute to eroding the bare topsoil, resulting in nutrient depletion and declining soil fertility (Chemonics International Inc. 2000; MoNP 2009; GIZ 2018). According to estimations, annual soil loss in Armenia is approximately 8 million t, ranging from 1 t/ha/yea in well-managed pastures to over 40 t/ha/year in degraded and sparsely covered lands (Chemonics International Inc. 2000). In rural areas, the use of manure as fuel for heating and cooking is another fact leading to a declining soil fertility because even more nutrients are extracted from soils without being returned to the grasslands (Babayan et al. 2011; Kochnakyan et al. 2014). Subsequently, the productivity, quality and ability of pastures to sustain future livestock production declines as well (Chemonics International Inc. 2000; GIZ 2018). This is confirmed by a study conducted in the frame of the World Bank's CARMAC project which found that plant dry mass production in overgrazed pastures in Geghadzor is currently around 30% below the potential yield (Madatyan 2011).

2.5.3. Change in vegetation cover and composition

Besides soil erosion, the vegetation of grasslands has changed and plant species diversity on near-by and remote pastures has decreased simultaneously (Chemonics International Inc. 2000; Madatyan 2011; Mezhunts and Navasardyan 2014; Vardhanyan et al. 2014). Especially the significant loss of valuable fodder species, mainly legume species, is of concern for livestock husbandry (ibid.). Legumes not only are considered as protein rich and thus highly nutritious plants for grazing animals, but are also known for nitrogen fixing and soil stabilisation capacities (Tovmasyan 2015b).
However, a study found that «[s]pecies diversity may only be a fifth of that of the original habitats as a result of overgrazing, particularly in lower subalpine meadows and steppe areas» (Chemonics International Inc. 2000).

At the same time, the share of dominating, unpalatable and undesired domestic weed species in grassland vegetation is growing gradually (Chemonics International Inc. 2000; MoNP 2009; Fayvush and Tamanyan 2014; Vardhanyan et al. 2014; CARMAC 2016; RA 2019). A list of

native expansive plant species which are increasingly penetrating into pastures and meadows – including the Aragatsotn marz – are summarised in **Table 4**. Many of these so-called pasture weeds are harmful to grazing livestock, either due to physical characteristics like thorns or due to their biochemical composition (Tovmasyan 2015b; RA 2019). Not being suitable as fodder species themselves and by supressing valuable fodder species, expansive pasture weeds not only reduce the quality of grasslands but also decrease the effective pasture area available for grazing livestock (Vardhanyan et al. 2014; Tovmasyan 2015b). Consequently, this causes economic losses to livestock keepers (ibid.).

Table 4: Expansive plant species spreading on pastures and grasslands in Armenia (source: adapted from Fayvush and Tamanyan 2014; Vardhanyan et al. 2014; Tovmasyan 2015b; Aleksanyan and Fayvush 2016; RA 2019).

Botanical name	Common name	Comments
Acantholimon spp	Prickly thrift	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Achillea filipendulina	Fearnleaf yarrow	–
Alliaria petiolata	Garlic mustard	–
Allium spp.	Wild onions	Biochemical components can alter smell, taste and/or colour of meat and milk
Anemone fasciculata	n/a	In the cases of overgrazing this species spreads intensively in pastures of subalpine and alpine mountain belts
Anthemis cotula	Stinking camomile, mayweed	Biochemical components can alter smell, taste and/or colour of meat and milk
Anthemis melanoloma	Mayweed	Biochemical components can alter smell, taste and/or colour of meat and milk
Anthemis triumfettii	Dogfennel, mayweed	Biochemical components can alter smell, taste and/or colour of meat and milk
Astragalus aureus	Tragacanth	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Astragalus galegiformis	Tragacanth	Very intensively distributing and penetrating into natural ecosystems, according to forecasts it will distribute in whole northern Armenia, current area of infestation: 15'000 ha
Caltha polypetala	Giant marsh marigold	In case of overgrazing it forms dense monodominant communities
Carduus crispus	Curly plumeless thistle	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Carthamus turkestanicus	Distaff thistle	Biochemical components can alter smell, taste and/or colour of meat and milk
Centaurea iberica	Iberian star-thistle	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Centaurea solstitialis	Yellow star-thistle	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Chondrilla juncea	Devil's grass	–
Cicuta virosa	Cowbane	Poisonous
Cirsium incanum	White-felted thistle	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Clematis orientalis	Oriental virginsbower	–
Conium maculatum	Hemlock	Poisonous
Conyza canadensis	Horseweed	–
Crupina vulgaris	Common crupina	Intensively spreading in the steppes of Armenia, especially as a result of overgrazing in the pastures

Table 4 (continued)

Botanical name	Common name	Comments
Danthonia spp.	Heath grass	–
Echinops spp	Globe thistles	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Eryngium campestre	Common eringo	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Euphorbia esula	Leafy spurge	Poisonous
Euphorbia marschalliana	Spurge	Poisonous
Euphorbia virgate	Leafy spurge	Poisonous
Geranium tuberosum	Cranesbill	Spreading intensively in the disturbed habitats; in abandoned fields it forms monodominant communities; it is abundant in steppes in Armenia (in the cases of overgrazing).
Goebelia alopecuroides	n/a	–
Heracleum trachyloma	Hogweed	Hard and inedible for grazing livestock, current area of infestation: 17'000 ha
Hyoscyamus niger	Henbane	Poisonous
Lavendula spp.	Lavender	–
Lepidium ruderale	Peppercress	Biochemical components can alter smell, taste and/or colour of meat and milk
Leucanthemum vulgare	Oxeye daisy	–
Melampyrum pratense	Cow wheat	Biochemical components can alter smell, taste and/or colour of meat and milk
Myosotis alpestris	Forget-me-not	Biochemical components can alter smell, taste and/or colour of meat and milk
Onobrychis cornuta	Sainfoin	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Onopordum acanthium	Cotton thistle	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Onopordum armenum	Cotton thistle	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Picnomon acarna	n/a	Widely distributed in Armenia from the lower to upper mountain belt. Grows mainly in the disturbed habitats and fields, also grows in pastures (in cases of overgrazing).
Polygonum alpinum	Alpine knotweed	Intensively spreading in pastures of upper mountain belt and subalpine belt of Armenia, especially in cases of overgrazing
Ranunculus sceleratus	Cursed buttercup	Poisonous
Rhynchocorys orientalis	n/a	In the last decades it spread very intensively in the subalpine pastures (as a result of overgrazing) and in the abandoned fields.
Rumex crispus	Curly dock, sorrel	Hard and inedible for grazing livestock
Seseli hippomarathrum	Hippomarathrum	Hard and inedible for grazing livestock
Silybum marianum	Milk thistle	Biochemical components can alter smell, taste and/or colour of meat and milk
Stipa capillata	Feather grass	Certain structural characteristics (e.g. thorns) can cause skin disorders, peroral and stomach damage, contamination of wool
Tanacetum parthenium	Feverfew	–
Thlaspi arvense	Field pennycress	Biochemical components can alter smell, taste and/or colour of meat and milk

Table 4 (continued)

Botanical name	Common name	Comments
Tripleurospermum transcaucasicum	Mayweed	Very intensively distributing all-over in Armenia and in all mountain belts, in meadows and wetlands, especially as a result of overgrazing, very resistant to grazing
Varatrum lobelianum	False hellebore	Poisonous
Veratrum album	Mullein	Intensively spreading in pastures in the upper mountain and subalpine belts of Armenia, especially in cases of overgrazing
Verbascum laxum	Mullein	Hard and inedible for grazing livestock
Verbascum pyromidatum	Mullein	Hard and inedible for grazing livestock
Xeranthemum squarrosum	n/a	Common from lower to upper mountain belt of Armenia, as a result of overgrazing, the density of populations in steppes and semi–deserts increases significantly

Among the most common expansive plant species in Armenia which are considered as pasture weeds are thistles, mayweeds, hogweed and tragacanth. According to literature, the hogweed *Heracleum trachyloma* infested about 17'000 ha all over in Armenia in the past decades (Aleksanyan and Fayvush 2016). The tragacanth species *Astragalus galegiformis* (see **Figure 4**) also has expanded aggressively and is estimated to cover an area of 15'000 ha in total (ibid.). With 119 species, *Astragalus* is the largest genera among many different genera native to Armenia (Fayvush and Tamanyan 2014). *Astragalus* is also known under the name milk vetch or locoweed (MoA 2008; Wiersema and León 2013; USDA 2018). The name locoweed comes from the Spanish word loco which means crazy and is attributed to the effect of certain *Astragalus species* which are poisonous to livestock if grazed over a period of 2-3 weeks (Armstrong no date; USAD 2018). Eventually, the toxic components of these *Astragalus species* can cause neurologic damages which lead to (i) abnormal behaviour (e.g. lethargy and depression), (ii) reduced feed intake and thus weight loss, (iii) diminished fertility and abortions as well as (iv) heart failure if grazed at high altitudes (ibid.). According to the government, such locoweeds are also spreading in Armenia, but no particular species are mentioned (RA 2019). In the United States, woolly locoweed (*Astragalus mollissimus*), spotted locoweed (*A. lentiginosis*) and garboncillo (*A. wootonii*) are commonly known as locoweeds (USDA 2018). These species could also grow in Armenia, considering the large number of *Astragalus species* native to the country.

Figure 4: *Astragalus galegiformis* (source: Murtazaliev no date).

Whereas *A. galegiformis* is a perennial high grass, other Astragalus species like *A. aureus, A. gummifer, A. adscendens* and *A. microcephalus* grow as spiny cushion shrubs (Ahmadi Gavlighi 2013; Fayvush 2020, personal communication; Armstrong no date). The latter three also are known as source of resins and gum tragacanth which is produced from the viscous sap of the plants (Armstrong no date; Ahmadi Gavlighi 2013; Featherstone 2015). The sap contains polysaccharides consisting form the water-soluble tragacanthin and the water-insoluble bassorin which swells to gel if mixed into water (ibid.). Due to this characteristic of gum tragacanth, it is widely used as natural thickener and emulsifiers (i.e. E-number E413) in cosmetic, drug and food industry (ibid.; Li et al. 2014). Gum tragacanth is mainly produced in the Middle East and there predominantly in Iran where it is seasonally harvested (Armstrong no date; Ahmadi Gavlighi 2013). The gum tragacanth is produced in the taproot where it swells during the hot summer months (ibid.). The gum can then be extracted from the taproot by making a small incision from where the gum is exuding in form of flakes or ribbons (ibid.).
Astragalus membranaceus is another species that is relatively well-known because its root is used in the traditional Chinese medicine (Armstrong no date; Li et al. 2014).
Li et al. (2014) report that crude extracts and isolated constituents from at least 46 *Astragalus species*, including *A. galegiformis* and *A. microcephalus*, have been research and have shown «[…] anti-inflammatory, immunostimulant, antioxidative, anti-cancer, antidiabetic, cardioprotective, hepatoprotective, and antiviral activities». Regarding *A. galegiformis* and *A. microcephalus,* different compounds can be extracted from the stem and the leaves (ibid.).

However, belonging to the family of *Leguminosae*, *Astragalus* is most commonly used as feed resources for grazing livestock and wild animals (Li et al. 2014). Generally, no information in English was available regarding if *Astragalus* is used for specific purposes in Armenia or how and which species are used. According to literature it can be stated that thorny tragacanth steppes are part of the vegetation in mountain steppes in Armenia where they cover quite large areas (MoNP 2009; Fayvush et al. 2013; BSC 2017; RA 2019). Nevertheless, it could not be identified which specific *Astragalus species* are included in the thorny cushion vegetation of tragacanth steppes. It is assumed that tragacanth steppes will expand their territory as a consequence of climate change (RA 2015; RA 2019).

In Geghadzor and Kuchak, pasture weeds have expanded increasingly during the past years as a result of pasture mismanagement, contributing to a loss of pasture lands. Especially farmers in Geghadzor stated that a certain pasture weed with a strong odour is heavily invading their pastures (about 1’000 ha) which leads livestock to reject grazing in the area of the weed (ACB 2014). There were assumptions that this pasture weed could be a *Festuca species*, although it could also be possible that it is an *Astragalus species* which is also known to spread aggressively in mountainous areas in Armenia (ibid.; Fayvush and Tamanyan 2014; Fayvush et al. 2015).

2.6. Impact of climate change on livestock husbandry

As the agricultural sector is one the most important drivers for poverty alleviation, employment provision (ca. 45%) and economic development (ca. 20% of GDP), Armenia is highly vulnerable to climate change (WB 2012; Melkonyan 2015). Especially the rural population (about 1 million) whose livelihoods are heavily dependent on agriculture will experience the impacts of climate change (Mezhunts and Navasardyan 2014). Forecasts assume that until 2050, the temperature will rise by 1.6-2.2°C, precipitations will decline between 7-10% in summer and early autumn (June-September) and extreme rainfall events will increase by 22-32% (WB 2012; USAID 2017). For instance, this will enforce the ongoing biodiversity loss and soil erosion, which already negatively affect livestock husbandry, pastures and meadows (ibid.). According to the Third National Communication on Climate Change (RA 2015) grazing areas in the subalpine and alpine belt will diminish by 19% and 22%, respectively, by 2030 because reduced rainfall and more frequent droughts will result in a water deficit. Semi-deserts and mountain meadow steppes in turn are forecasted to rise by 17% (ibid.). It is estimated that productivity of pastures will decrease by 4-10% whereas hayland yields could drop by 7-10 % (ibid.). Grazing lands with low productivity are expected to increase by 23% until 2030 (RA 2015).
Although higher temperatures and a reduced snow cover in the alpine meadow belt could lead to an earlier start of the grazing season and the establishment of new grazing sites, it is unlikely that these will compensate for the declined and more variable precipitations (WB 2012; USAID 2017). Generally, forecasts assume that livestock productivity will decrease substantially due to the increasing temperatures and the decreasing availability and quality of natural feed and water resources (USAID 2017; RA 2019). By 2013, meat, milk and wool production are expected to drop by 15’000 t, 52’000 t and 116’000 t, respectively (ibid.).

In the Aragatsotn marz, climate change will most likely cause more hailstorms, droughts and early frosts (WB 2012). In the past years, extreme events like droughts, mudslides, spring frosts, floods and hail, caused annual damages of 10-20 million US$ in the whole country, from which a huge share was attributed to hailstorms (WB 2012; Vardhanyan et al. 2014; USAID 2017). Such events not only cause economic losses, but also endanger rural livelihoods and food security (ibid.). Therefore, it is necessary that the agricultural sector in Armenia, especially livestock husbandry, starts to use its potential for climate mitigation. On the one hand, carbon sequestration can be increased by optimising the pasture management and increasing pasture productivity (WB 2012). Further improvements could be achieved by introducing more productive grass species to increase fodder production for grazing livestock and carbon capture (ibid.). Integrating concentrates or protein-rich fodder crops like alfalfa (*Medicago sativa*) into the feed ration of grazing livestock could help in reducing methane emissions (ibid.). Crossbreeding or introducing new breeds is another option to increase productivity of the livestock sector and thereby reduce the emissions of greenhouse gases, although it needs to be assessed carefully if improved breeds can cope with the local conditions. Improvements also need to be achieved in manure management, not only to recycle manure and use it efficiently, but also to diminish methane and nitrous oxide emissions by improper manure storage (ibid.).

3. Material and methods

3.1. Research objectives

In the frame of the context described in chapter 2 and focusing on two communities in north-western Armenia, the goals of this study field project were:

- To identify current pasture management practices
- To determine expansive plant species (besides *Astragalus galegiformis*) which are spreading on pastures
- To map the areas where expansive plant species are spreading
- To assess how the communities perceived the spread of expansive plant species in the past 10 years and the communities' influence on the spread
- To identify if and what control strategies these communities use against expansive plant species
- To evaluate the impact of expansive plant species on livestock husbandry and people's livelihood.

3.2. Study sites

The communities of Geghadzor and Kuchak located in the Aragatsotn marz have been selected as target communities because both have already participated in several projects on pasture management and rehabilitation by the GIZ and the World Bank. Another factor for selection was the good accessibility by car leaving from Yerevan. Further information about the selected target communities can be found in chapter 2.1.

3.3. Expert interviews

The data collection was based on expert interviews by means of a questionnaire which was previously prepared at the ACE taking into account various aspects of the above-mentioned objectives. The overall goal of the expert interviews was to assess how current pasture management practices are linked to the increasing spread of expansive plant species on pastures in the communities of Kuchak and Geghadzor.

The interviews were conducted with local experts on livestock husbandry and pasture management, i.e. community leaders, the heads of the pasture user cooperatives and large farmers with big livestock herds. Artur Hayrapetyan, Adviser on Integrated Erosion Control at GIZ, arranged for the contact to the respective experts in Geghadzor and Kuchak.

The questionnaire was prepared in English with minor adaptations for the different groups of experts and was then translated into Armenian. Before going to the field, the involved AUA student was introduced to the project and questions regarding the questionnaire were discussed. For data transcription, direct English translation of answers to open question was provided by the AUA student and was sufficient to extract the relevant data. Most of questions in the questionnaire were based on single or multiple choice or relied on simple numbers which were comparatively easy to evaluate. The questionnaire was created with Maptionnaire which is a map-based tool used for surveys focusing on public participation. The basic version of the questionnaire can be found in Annex 1.

The interviews were conducted as follows: On the 12th of October 2019, four expert interviews, with three farmers and the head of the pasture user cooperative, were conducted in Geghadzor. In Kuchak, three experts were interviewed in total. Two expert interviews (1x the leader of Aparan municipality, 1x member of Ministry of Economics and of pasture user

cooperative) were conducted on the 16th of October 2019, one expert (head of pasture user cooperative) was interviewed on the 17th of October 2019.
The collected data was descriptively analysed at the University of Hohenheim after finalising the field work in mid-October 2019.

3.4. PPGIS and Maptionnaire

A mapping component was included in the questionnaire by using the internet-based tool Maptionnaire in the context of a PPGIS (Public Participatory Geographic Information System) approach. Therefore, the local experts were asked to indicate on an online map where the respective expansive plant species are spreading and when they first have been noticed on the pastures. The goal was to create maps showing the spatial spread of these plants in Kuchak and Geghadzor communities in the past 10 years.

3.5. Literature review

The field study was complemented by a literature review on pasture management, land and ecosystem degradation, prevention of expansive plant species and their potential use in the context of Armenia. The literature review moreover aimed to reveal if there are any suitable control strategies against expansive plant species used in other countries which could be implemented in Armenia, too. Relevant literature was additionally provided by the German Society for International Cooperation (GIZ) which collaborated with the UHOH student and has extensive experience in the field of sustainable pasture management and pasture rehabilitation in Armenia.
The following key words were combined using the operator AND to find literature in the databases of ScienceDirect and ResearchGate: ‘agriculture’, ‘livestock’, ‘pastures’, ‘grasslands’, ‘management’, ‘rehabilitation’, ‘monitoring’, ‘degradation’, ‘biodiversity’, ‘ecosystems’, ‘expansive plant species’, ‘weed control’, ‘Armenia’, ‘South Caucasus’. Some papers and reports were found by consulting the bibliography of previously found literature.
The reviewed literature will be uploaded later on to an online knowledge exchange platform of the GAtES project.

3.6. Issues during the project

Reliance on partners

There was a strong reliance on external parties like GIZ and SDA (Strategic Development Agency) to access information about the target communities and pasture management in Armenia in general. Although Kuchak and Geghadzor have participated in different projects about pasture management, there were hardly any reports published or they were only available in Armenian. Furthermore, the UHOH student was also dependent on partners to get in touch with the communities for data collection.

Elaboration of questionnaire and preparation of data collection

Initially it was planned to do focus group discussions, but the envisioned moderator had to decline because of time reasons. As the method of data collection was changed, the questions prepared for the focus group discussion had to be adapted. In addition, the process of recruiting an AUA student to accompany data collection took longer than expected which was amongst the reasons why there was in the end not sufficient time to pre-test the questionnaire with people from the communities and to have a training for the work study about conducting interviews and what to pay attention to during data collection. as well as there was no time left

to spend some day in the communities and get a proper overview of the situation of expansive plant species. The delays regarding the preparation of data collection also contributed to a lack of time to conduct several field visits in Geghadzor and Kuchak in order to determine pasture weeds and get an impression of pasture degradation in these communities.

Conduction of data collection

The interviews could not always be conducted as planned due to misunderstandings and unforeseen changes behalf of the local experts. In Geghadzor, one wished-for expert could not come to the interview because he was ill, instead his son was interviewed. In Kuchak, the contact person who was also an expert to be interviewed did not know that the UHOH student would come for the interviews although it was confirmed the day before. Therefore, the situation was a little bit chaotic and the UHOH and AUA student returned the day after to do one more interview.

Maptionnaire

Although internet connection was good in both communities, the Maptionnaire tool did not function as intended. The respondent's answers were not deleted after completing the questionnaire and had to be deleted by hand which was too time consuming. Eventually, the questionnaires were filled in on paper. Additionally, there were some issues with the mapping itself. Unfortunately, local experts in Geghadzor could not indicate the areas for the expansive plant species because the particular areas were covered by snow on all maps available on Maptionnaire. Instead, the interviewees showed on a big paper map provided from head of pasture user cooperative where the areas with heave weed infestation are located. The UHOH student took pictures and notes to create a map with Photoshop. In Kuchak, the local experts could not indicate specific areas of infestation as they stated that expansive pasture weeds are growing on all pastures in the community.

Recommendations

For the next students taking part in the exchange programme, it would be recommendable to define the topic as narrow as possible while still being in Germany. This will allow working on the questionnaire before the actual exchange starts and field work in Armenia can begin sooner. Furthermore, the AUA student(s) collaborating with the UHOH student(s) should be identified and involved as soon as possible.

4. Results

4.1. Seasonal grazing management

Grazing season

In both communities, the start of grazing season varies depending on annual weather conditions. According to the experts in Geghadzor, the grazing season can start between mid-April and end of May, but usually begins at the end of April. The end of grazing season can be between end of October and beginning of December, but mostly it finishes at the end of November. In Kuchak, the grazing season begins between mid-April and beginning of May, whereas the end of grazing season ranges from end of October to end of November.
In general, this implies a grazing season of 6-7 months on average in both communities.

Factors determining grazing time per pasture

According to the experts, the size of pasture is the predominant factor which determines the grazing time per pasture (6/7). 3 out of 7 experts additionally allocate some importance to the pasture condition. Two interviewees named also the number of animals to be important to determine the grazing time per pasture.

In Geghadzor, the three farmers interviewed only consider the size of the pasture decisive for the grazing time per pasture whereas the head of the pasture user cooperative also named pasture conditions and number of animals as important factors. Furthermore, he explained that size and condition of a pasture as well as the quantity of animals are considered in the pasture management which is based on rotational grazing.

In Kuchak, the main factors determining grazing per pasture were size and condition of pasture, each named by 2 of 3 interviewees.

Factors determining number of animals going to community pastures

The most important factor determining the numbers of animals going the community pasture seems to be the availability of summer fodder (6/7), meaning how much grass is growing on the pastures. Second most decisive factors are the availability of shepherds (4/7) and availability winter fodder (4/7), i.e. stocks of hay or supplementary feeds. If famers do not have a lot of winter fodder, the importance of community pastures as feed resource increases. However, all experts stated that usually all animals go to the pastures. **Table 5** shows the animals stocks [heads] in Kuchak and Geghadzor according to the data provided by the interviewed experts.

Table 5: Animals stocks [heads] in Geghadzor and Kuchak in 2019.

Animal stocks [heads]	Geghadzor	Kuchak
Cattle	765	1’825
from which are dairy cows	*435*	*730*
Sheep	1880	650
Goats	0	70
Pigs	36	380
Poultry	1’152	4’000
Beehives	127	320

Migration to remote pastures

In Geghadzor and Kuchak, animals have to walk to access remote pastures as there is no transport available by truck and road conditions are usually bad. 6 out of 7 experts stated that remote pastures are more often used during the grazing season. Only one expert in Geghadzor said that pasture close to the community are more frequently used than the remote ones.

Responsible for herding

All experts furthermore stated that shepherds are responsible for guarding the livestock on the community pastures, even though one expert said that farmers in Kuchak sometimes take part in herding, too. Although the decreasing availability of permanent shepherd was mentioned to be a problem by a GIZ expert, none of the experts considered the availability of permanent shepherds to be problematic.

Assessment of fodder provision by community pasture for grazing livestock

6 out of 7 experts assessed the community pastures to provide just enough fodder for the grazing livestock, only one expert in Kuchak evaluated the fodder provision as insufficient.

Development of grazing livestock in the past 10 years (2009-2019)

The statements regarding the development of the grazing livestock differed between Geghadzor and Kuchak. Whereas the experts in Kuchak said that the number of grazing livestock decreased (2/3) or remained on the same level (1/3) during the past 10 years, the statements were contradictory in Geghadzor. The three interviewed farmers indicated an increase in stocks of grazing animals, although the head of the pasture user cooperative stated that stocks had decreased.

4.2. Assessment of community pastures

Conditions of community pastures

According to numbers provided by the head of the pasture user cooperative, pastures in Geghadzor comprise 1'360 ha. As already mentioned by Madatyan (2011), there are also 2'500 ha which are not considered as agricultural land by the community, but still are used as pastures. In Kuchak, the experts indicated the pasture area to be 1'555 ha which is the same name that was reported by CARMAC (2016) as well.

In both villages, the experts generally evaluated the current conditions of community pastures as satisfactory (6/7). Only one expert in Kuchak assessed the community pasture conditions as bad. In Geghadzor, all experts additionally stated that the conditions of community pastures have worsened in the last 10 years, i.e. from 2009 to 2019. In Kuchak, 2 out of 3 experts did not notice any deterioration of community pastures, only one found the conditions to have worsened.

Level and type of degradation on community pastures

All experts in Geghadzor indicated that there are a few problems with degradation on community pastures. In Kuchak, one respondent assessed the level of degradation problems as medium, whereas the other two experts considered degradation issues on community pastures to be severe.

The main degradation problems in Kuchak and Geghadzor are the spread of pasture weeds (6/7), erosion (4/7) and a lower productivity of pastures (4/7) resulting in a lower fodder availability for grazing animals. Especially in Kuchak, erosion and pasture productivity were named as examples of ongoing pasture degradation. Interestingly, farmers interviewed in Geghadzor only mentioned the spread of pasture weeds as degradation problem, whereas the head of the local pasture cooperative additionally named erosion (see **Figure 4**) and lower pasture productivity.

Figure 5: Low vegetation cover and soil erosion in a remote pasture in Geghadzor.

Abandonment of pastures and its reasons

In Kuchak, the experts uniformly answered that there are pastures out of use. Main reasons are the absence of watering points (3/3) and the bad quality of roads (3/3). Further reasons stated by one expert are the spread of weeds, the daily milking procedure, remoteness and erosion.

In Geghadzor, there was a discrepancy between the farmers and the head of pasture use. The latter stated that some pasture remain unused whereas all 3 farmers indicated that there are no community pastures which are not actively used. According to the head of the pasture cooperative, the spread of weeds and remoteness are reasons for pasture abandonment.

Development of pasture quality from community to remote pastures

The 3 experts interviewed in Kuchak agreed that the pasture quality is increasing from the village towards remote areas. In Geghadzor, farmers consider the pasture quality to decrease from village to remote areas whereas the head of pasture cooperative indicated a higher quality of remote pastures compared to close-by village pastures. Farmers verified their statement by the reduction in milk yield when animals graze on remote pastures.

Maintenance measures for community pastures

In Geghadzor, all experts named rotational grazing to be the main measure to maintain or improve community pastures. The 3 farmers interviewed also indicated fencing as a maintenance measure, but this was in fact only done in 2018 in the frame of a GIZ trial on pasture rehabilitation and was not continued, nor by the community nor by farmers or the pasture user cooperative. In Kuchak, the 3 experts uniformly answered that nothing is undertaken to maintain or improve pastures.

4.3. Determination of existing pasture weeds

In Geghadzor, the experts mentioned a plant called «push» (in Armenian) to be one of the most problematic expansive pastures weeds which could be identified as *Astragalus microcephalus* (see **Figure 6**) with the help from George Fayvush and Alla Aleksanyan from the Institute of Botany in Yerevan. In Kuchak, the same plant was stated to be the most challenging pasture weed, spreading on all pastures of the community, near-by and remote ones. In contrast to Geghadzor, the experts in Kuchak had no specific name for *Astragalus microcephalus*, as it is commonly known simply as «the» pasture weed. Generally, *Astragalus microcephalus* grows as spiny cushion shrub why grazing livestock does not feed on it (Fayvush 2020, personal communication).

Figure 6: *Astragalus microcephalus* is expanding in pastures in Geghadzor and Kuchak.

Figure 7: Alchemilla species found in a remote pasture in Geghadzor.

Another pasture weed which interviewees in Geghadzor named to be very expansive is «gndzer» (see **Figure 8**). The plant is said to have a very strong odour which prevents livestock to graze around the plant. According to George Fayvush (2020, personal communication), the plant identified by people in Geghadzor as «gndzer» could be a *Sempervivum species*, maybe *S. transcaucasium* or a *Sedum species*. However, the name «gndzer» was not known to him and it might be that the smelly plant could be an *Alchemilla species* which was observed quite often during a field visit in Geghadzor (see **Figure 7**).

Figure 8: *Sempervivum transcaucasium* or *Sedum species* found in remote pasture in Geghadzor.

Although not more plants were mentioned by experts in Geghadzor to be aggressively expanding, it was observed during a field visit and around the village that a lot of thistles and also sorrels (see **Figure 9** and **Figure 10**) are growing in near-by pastures which is a clear sign of disturbed habitats. The genera were identified again with the support of George Fayvush.

Figure 9: *Carduus species* (left) and *Rumex species* (right) found in close-by community pasture Geghadzor.

Figure 10: *Centaurea species* or *Cirsium species* found in close-by community pasture in Geghadzor.

As the Maptionnaire tool did not work as expected, the areas with heavy infestation of pasture weeds in Geghadzor were identified with the map which is used for planning the pasture management and was originally implemented by the CARMAC project. As **Figure 11** shows, the heavily invaded areas are located rather in the remote, underused summer pastures and not on the community-close pastures. Unfortunately, it was not possible to visit these areas why the uncertainties around the «gnzder» plant could not be solved.

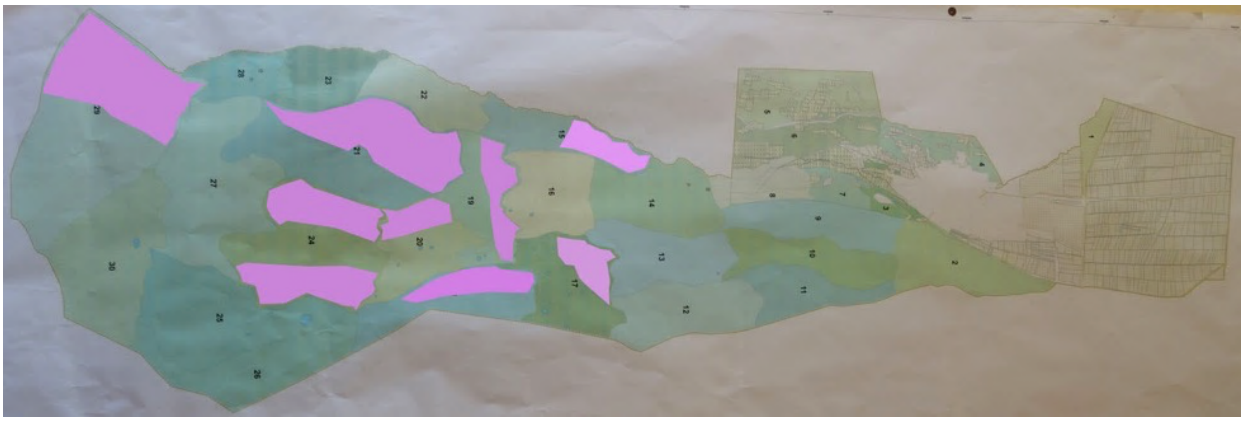

Figure 11: Pasture areas with heavy invasion of pasture weeds (in purple) in the pasture lands of Geghadzor.

In Kuchak, experts did not mention any other pasture weeds than *Astragalus microcephalus* to be increasingly expanding. Nevertheless, they emphasized the great impact of the weed on pasture use (see **Figure 12**). However, during a short field visit, it became apparent that thistles also grow intensively on the pastures, too, as it was already observed in Geghadzor (see **Figure 12** and **Figure 13**).

Figure 12: Close-by community pasture in Kuchak which is heavily invaded with *Astragalus microcephalus* and *Eryngium billardierei* (right picture).

Figure 13: *Cirsium species* found in a close-by community pasture in Kuchak.

4.4. Control strategies against pasture weeds

Reasons for spreading pasture weeds

All experts considered the main reason for the increasing spread of pasture weeds in the changing climate (7/7), followed by bad soil quality and fertility (5/7).

In Kuchak, all experts mentioned the bad infrastructure to access pastures as an additional reason contributing the increasing expansion of pasture weeds. Furthermore, 2 out of 3 experts stated that the grazing animals sometimes are not long enough on the same pastures which would also contribute to the spread of pasture weeds. The third expert indicated the opposite, i.e. that grazing animals stay too long on the same pasture leading to spreading pasture weeds.

In Geghadzor, two farmers considered erosion as a reason because it would contribute to a declining soil fertility and thus support the further spread of pasture weeds.

Awareness and application of control measures against pasture weeds

In total, 5 experts were aware of control measures against pasture weeds. In Geghadzor, all 3 farmers mentioned burning and chemical control as control measures. Surprisingly, the head of the pasture user cooperation stated not to know any control measures against pasture weeds. In Kuchak, 2 of 3 experts answered that they know burning, chemical control, cutting/chopping as well as biological control as potential control measures against spreading pasture weeds.

In both communities, none of the mentioned control measures is currently applied. In the past, chemical control was used and according the interviewees' statements it was effective against the weeds. The main reason why these control measures are not used in both villages is the high costs of weed control and lacking money, respectively (3/5). The bad road conditions (3/5) and difficulties to handle the proper application of control measures (2/5) are other reasons why they are not implemented by the villagers.

None of the experts interviewed was furthermore aware of any alternative use of common pasture weeds.

4.5. Impact of pasture weeds on livestock husbandry and livelihoods

All 7 experts emphasized that spreading pasture weeds affect livestock husbandry in terms of a decreasing availability of fodder production areas and grazing sites, leading to a reduced milk yield and subsequently a decline in income.

Two experts, one in Kuchak and one in Geghadzor, additionally mentioned that spreading weeds are problematic for crop production as well, especially in wheat fields. Another expert in Kuchak told that thorny weeds are increasingly covering roads, making it more difficult for shepherds and animals to walk on the road and leading to decreasing wool quality due to thorns.

4.6. Pasture user cooperative and pasture management plan

Assessment of pasture user cooperative

6 out of 7 experts assessed the respective pasture user cooperative as good, although one expert in Kuchak evaluated it as bad because it would not work sufficiently and efficiently, not assuring a proper implementation of the pasture management plan.

In Geghadzor, the 3 interviewed farmers appreciated in general the supporting function of the cooperative for local residents. In Kuchak, one expert was very fond of the tractors which were

bought by the cooperative because these are facilitating crop production and also have positive impacts on fodder production.

Implementation of pasture management plan
In Geghadzor, the farmers stated that they do not know about a pasture management plan. The head of the pasture user cooperative in Geghadzor said that the management plan works partly. In Kuchak, one expert stated that the pasture management plan is partly implemented whereas the other two experts said the plan does not work.

Reasons not to/only partly implement pasture management plan
The experts think the pasture management plan is not properly implemented because people are busy with other daily activities and worries why it is more convenient not to follow the plan (3/4). One expert in Kuchak also mentioned that lacking information and education on behalf of the farmers are reasons why the plan is not correctly implemented.

Necessary changes for a proper implementation of pasture management plan
The 2 expert in Kuchak who stated that the pasture management plan does not work in their community think that the following changes would need to be achieved that people would start following the management plan: The animal productivity in terms of meat and milk would need to increase as well as the fodder availability (pasture productivity). They indicated that the villagers do not yet see visible effects or benefits why the management plan is currently not properly implemented.

4.7. Relevant problems in Geghadzor and Kuchak

According to the interviewees (5/7), pasture weeds are the most relevant problem in the communities of Kuchak and Geghadzor. In Kuchak, all interview partner stressed the issue of lacking water access in remote pastures and the need for establishing watering points for the grazing animals. Another pressing problem mentioned by one person in each village is the bad condition of roads which not only complicates accessing remote pastures but also contributes to the difficulties in controlling the expansive pasture weeds. In Kuchak, one expert also considered erosion to be very problematic as it caused the villagers to abandon three pastures. Only one expert in Kuchak wanted to further comment on their need for official programs by the state and/or international organization to improve their pastures. This respondent stressed the wish of Kuchak village to continue the collaboration with GIZ as their pasture rehabilitation pilot project had a positive impact on pasture quality by reducing the expansive pasture weeds in the pilot area.

5. Discussion

5.1. Pasture management

Considering that pasture size was mentioned most by the experts (6/7) to be a main factor to determine the grazing time per pasture implies that there is some knowledge about pasture management. But of course, there are many other factors decisive how long a pasture should be grazed, for instance height and condition of vegetation cover, vegetation composition, regeneration capacity of species part of the vegetation, time of vegetation period as well as type and number of grazing animal (Tovmasyan 2015b).
A factor that certainly has an impact on developing a sustainable pasture regime is the declining availability of shepherds which was mentioned to be a problem by (4/7) experts. Shepherds have a crucial role in pasture management, e.g. Shepherds have an important role to play in establishing a sustainable grazing regime, i.e. following the grazing plan with correct timing etc. They would need to overtake important tasks in monitoring the state of pastures which would have impact of further planning of pasture management. However, if shepherds are not available, it is likely that near-by pasture will be overgrazed even more and remote summer pastures will be abandoned more frequently. This would result in further degradation of pasture lands.

A further point that seems to be problematic is the availability of reliable data. This was also observed during the interviews, especially in Geghadzor where farmers stated that livestock numbers have increased, whereas the head of the pasture user cooperative said stocks of grazing animals have declined. It is possible that that stocks of grazing animals might have dropped on average on the community level but have increased on some farms. According to the numbers provided by the head of the pasture user cooperative, within 5 years, cattle number would have more than halved from 1’849 in 2014 to 765 in 2019. In the same time, population number decreased form 1’253 in 2014 to 1’189 in 2018 which could partly explain the substantial decline in cattle as some inhabitants might have left the village (ACB 2014; MoDAT 2019b). However, if animal stocks would have decreased so tremendously, it could be assumed that farmers would know about that.
Similar inconsistency has been found in literature regarding data about pasture areas. Whereas the pasture area in Geghadzor was indicated to be around 3’800 ha by Madatyan (2011), official data from local authorities of the Aragatsotn marz stated pastures would comprise 358 ha (MoTAD 2019b). The same was found for Kuchak where the CARMAC (2016) project stated a pasture area of 1’555 ha and other sources indicated pasture lands of 350 ha (MoTAD 2019a) and 860 ha (BSC 2017).
However, these examples demonstrate the issues of data reliability which presumably has implication for pasture management as well. If the different stakeholders involved in pasture management do not rely on the same information or principles, for instance what is considered as pastures and not, it enforces problems during implementation. The different perceptions of different stakeholders were furthermore observed during the interviews, especially in Geghadzor, for example when assessing the pasture conditions. The head of the pasture user cooperative evaluated remote pasture to be of higher quality than near-by community pastures. Farmers on the contrary assessed the quality of remote pasture to be worse due to the fact that milk yields decrease when grazing livestock is brought to the summer pastures. Bad pasture quality can indeed be a reason for reduced milk yields, but it is more likely that

accessing remote pastures is very energy intensive for cattle and therefore milk yields are lower. That farmers seem not to be aware of the various factor impacting milk yields, could be a further hint of lacking agricultural education. To develop a sustainable pasture management, it is necessary that all stakeholder, including farmers and shepherds, understand the principles of proper grazing management. Therefore, there is a need for more agricultural education, technical and vocational training to stimulate capacity building among farmers and shepherds and to raise their awareness of the consequences for ecosystems and the future of livestock husbandry if current pasture management practices will not be changed and further improved.

5.2. Expansive pasture weeds

Although it was assumed that *Astragalus galegiformis* could be one of the expansive plant species in Geghadzor and Kuchak, *Astragalus microcephalus* was identified as one of the challenging pasture weeds in both communities. This is surprising in this sense, as the plant has not been mentioned anywhere in the literature used for this work, which deals specifically with expansive plants in Armenia. Only in Tovmasyan (2015) *Astragalus aureus* is listed as a problematic weed on grassland which also grows as thorny cushion bush. It is possible that *Astragalus aureus* and *Astragalus microcephalus* were confused. However, according to Alla Aleksanyan (2019, personal communication), *Astragalus microcephalus* is a plant that is common in the area around the Aragats massif.

The other concerning pasture weed with the strong odour in Geghadzor could not be determined beyond doubts. Although it is assumed that a *Sempervivum* or *Sedum species* might be the odorous weed preventing livestock from grazing, no similar cases or indications could be found in literature which would confirm this assumption. In ACB (2014) it was stated that a *Festuca species* could be the smelly pasture weed. Unfortunately, there was again no proof to be found in literature which could confirm this assumption. It is unfortunate that the problem with this pasture weed with the sharp odour has been known since 2014 and apparently has not yet been determined, although at that time Geghadzor was already part of the World Bank's CARMAC project.

However, according to literature a lot of thistles native to Armenia are increasingly expanding in the Aragatsotn marz as a result of overgrazing (Fayvush and Tamanyan 2014; Vardhanyan et al. 2014; Tovmasyan 2015b; Aleksanyan and Fayvush 2016; RA 2019). This could be confirmed during the short field visits in Kuchak and Geghadzor where thistles were aggressively invading near-by community pastures. Interestingly, these plants were not mentioned by the experts to be problematic. To be able to develop a specific plant for weed control it would be necessary to identify specific plant species and not only genera. Therefore, it is recommendable that further research should take place in both communities to precisely determine what weed species are most problematic on pastures. Moreover, for a next student project concerning pasture weeds it would be advantageous if the vegetation period is considered and the project is carried out in spring or summer. This project was conducted in autumn, which posed a problem for the identification of expansive pasture weeds, as it was at the end of the growing season and many weeds had already wilted.

5.3. Weed control strategies

It can be stated that regarding weed control, prevention is still the best strategy why a development towards sustainable pasture management is crucial for both communities. A reasonable and well-organised pasture use will be the basis to prevent a further spread of expansive pasture weeds like thistles or *Astragalus microcephalus*. For the latter, no

information could be obtained from literature about how it can be effectively controlled as it is not plant in the focus of research, at least not in terms of weed control. An alternative use of *Astragalus microcephalus* should therefore be considered, although the ultimate goal should still be to prevent further spread of the plant. As described in chapter 2.5.3, *Astragalus microcephalus* can be used for the production of gum tragacanth, which is reused as an emulsifier and thickener in the food and cosmetics industry (Armstrong no date; Ahmadi Gavlighi 2013; Featherstone 2015). However, more clarification is needed for this scenario, e.g. on production systems, processing and demand for gum tragacanth at national and international level. Yet, it might be a chance that an alternative use of the plant is not excluded per se, especially as this expansive pasture weed has already invaded large pasture areas and will probably be difficult to control on such vast areas. Of course, it would also be necessary to assess if rural population is willing to engage in such a business, assuming the external conditions would allow the production and processing of gum tragacanth.

To reduce the number of existing weed populations, it is generally suggested to choose an integrated weed management approach which combines mechanical, chemical and if possible, biological control strategies. In this regard it is especially important to know the specific variety of a plant species because different weeds can behave controversially to the same weed control measure (Aleksanyan 2019, personal communication). In Kuchak and Geghadzor, as suggested by Tovmasyan (2015b), it might be necessary that some heavily degraded and infested pastures and meadows need to be taken out of use for 2-3 years as last possible weed control strategy to rehabilitate pastures and reduce the pressure from pasture weeds on grassland ecosystems. A trial by GIZ in 2018 in both communities showed that this measure can have a great positive impact on pasture rehabilitation and thus supressing of weeds (Kieling and Mambreyan 2018). However, it can be stated that weed control, considering the extend of invasion in Geghadzor and Kuchak, is likely to take several years, especially when talking about thistles (Honisch 2019). Although thistles were not mentioned by the experts as a pasture weed, they should also be in the focus of weed control, as thistles are extremely persistent weeds and will spread more as pasture degradation progresses. Honisch (2019) recommends that pastures and meadows are regularly controlled by farmers and shepherds to prevent the further spread of individual plants and the development of so-called thistle nests. Individual plants should be controlled immediately, if possible, by pulling or digging it up together with the root (ibid.). If the thistles are already older, seed production and dispersal should be prevented, by removing the flower head (ibid.). To eliminate the nutrient reserves of the roots, a repeated cutting of the thistles is essential. Nontetheless, it is important to know the exact type of thistle and its behaviour in terms of nutrient translocation within the plant because at certain times during the growth cycle, cutting can trigger the growth of thistles (ibid.). In a next step, chemical control with selective herbicides is an option, particularly for individual thistles. Considering the rather fragile state of grassland ecosystems in Armenia, a chemical weed control needs to be assessed carefully, not only for thistles, but also for other weeds like *Astragalus microcephalus* which have invaded substantial pasture areas in Geghadzor and Kuchak. With regard to the large affected pasture areas, however, the feasibility of manual or mechanical weed control is uncertain because the mechanisation in Kuchak and Geghadzor is low and the existing machinery is generally obsolete and in poor condition (Bayer 2012; CARMCAC 2016). Yet, improvements in agricultural machinery could not only enable a more efficient and effective weed control, but also increase the productivity of fodder production (Akhbalyans and Mambreyan 2015). This in turn could have a positive

impact on pasture management, because insufficient quantity and quality of fodder produced for grazing livestock is a factor why early spring grazing and late autumn grazing is practised in Kuchak and Geghadzor (Madatyan 2011; Akhbalyans and Mambreyan 2015; CARMAC 2016). At these times, pasture plants are at a sensitive point in their vegetative cycle, which means that grazing can massively reduce the productivity of pasture vegetation (ibid.; Madatyan 2011; Tovmasyan 2015b). Thus, by avoiding grazing during early spring and late autumn, the pressure on grassland ecosystems could be reduced and could simultaneously stimulate their regeneration. Akhbalyans and Mambreyan (2015) state that improvements in agricultural machinery could not only be a measure to support an increasing productivity in livestock husbandry, but also could be seen as an incentive for farmers to agree on new terms of pasture management.

Besides weed control and improved pasture management (i.a. rotational grazing, fencing), there is also a need for additional agricultural activities to restore degraded pasture lands and increase their productivity (Madatyan 2011; Tovmasyan 2015b; GIZ 2018). This includes practices like fertilising grasslands (with manure or mineral fertilisers) and underseeding in areas with low vegetation cover (ibid.). In addition, bioengineering measures (e.g. construction of pile walls) to combat soil erosion and afforestation of heavily eroded and degraded areas will help to restore grassland ecosystems (GIZ 2018). Both communities already have been part of projects which aimed to introduce or at least test such activities, but it seems they could not yet be implemented on a long-term basis. In Geghadzor, experts mentioned that rotational grazing is practised in the community to maintain or improve pastures. In Kuchak, exports said that no maintenance measures are undertaken in the community, although it has been part of the CARMAC project as well. Regarding Geghadzor, it was reported that the especially the pasture user cooperative was against reforestation measures because there was already a lack of pasture lands (ACB 2014). It is further stated that members of the cooperative also were not convinced of the sustainable pasture management plan, because hardly any or no positive effects have been visible in the community yet. Of course, this could be attributed to the fact that people do not fully follow the pasture management plan according to the statements of the interviewed experts.
However, a functioning pasture user cooperative is fundamental to achieve an improved and more sustainable pasture use. Taking into account that the CARMAC project was implemented in Geghadzor in 2011, the question arises what are the exact reasons that prevent the proper implementation of the pasture management plan and what changes would be necessary to achieve it. The introduction of certain financial incentives by the government for applying bioengineering measures, weed control and protection of pasture lands might help to shift towards a more sustainable pasture management and to convince farmers and shepherds that these measures have a positive effect in the long term. It is not only in the interest of the farmers that pasture lands can be preserved, but also for the public to ensure the services provided by grassland ecosystems in the future as well. Nonetheless, the question of financing remains open and would need to be addressed by local authorities, national organizations and international development agencies which are already active in the context of sustainable pasture management.
Another issue that could be studied in the context of sustainable pasture use, the pasture user cooperative and obstacles to its successful implementation is land ownership. Currently, the vast majority of pasture lands in Kuchak and Geghadzor belongs to the community (Madatyan 2011; ABC 2014; CARMAC 2016; BSC 2017). It might be interesting to investigate whether

the willingness of the rural population to invest and implement pasture maintenance measures would increase when the land would belong to private individuals and not to the community. Considering that natural fodder areas such as pastures and hayfields are the basis for animal husbandry and thus the livelihood of the population in Kuchak and Geghadzor, the impression often arose during the expert interviews that both communities show a limited willingness to initiate improvements in pasture use and lacking maintenance measures themselves. The reasons for this are probably that such interventions entail certain risks for the investor and that the financial resources of the community and individuals are limited. For this very reason, the creation of pasture user cooperative seems actually to be a good approach of reducing certain risks through joint action in the community, while at the same time increasing the scope and effect of the realised measures.

One additional and crucial point in the context of controlling pasture weeds and managing pastures on a sustainable basis is the improvement of infrastructure in terms of roads, watering points, stables and accommodation for shepherds (Madatyan 2011; Bayer 2012; ACB 2014; BSC 2017). This also requires the support of government as the communities most likely will not be able to raise the financial means for these necessary investments. Better roads not only would improve the access to remote summer pastures, but also would facilitate to accomplish pasture maintenance and weed control measures. Furthermore, improved road conditions could also provide an opportunity to consider mobile milking parlours (see **Figure 13**) which are already in use in many places in Europe, especially in grassland dominated areas.

Figure 14: A mobile milking parlour used on a pasture by a farmer in Poland (source: Gaworski and Kic 2017).

Another advantage of a mobile milking parlour is that it can reduce the need for grazing livestock to cover long distances which simultaneously could reduce the trampling of certain paths or roads. In systems with mobile milking parlours, the milk is collected in tanks and can then be transported for processing etc. (Gaworski and Kic 2017). In Switzerland, there is in addition a project ongoing regarding the construction of mobile accommodation for shepherds which should provide more flexibility and comfort (BFH 2019).

All in all, a cross-sectoral approach and interdisciplinary cooperation seem essential to prevent the progressive spread of expansive plants and pasture weeds and to initiate sustainable pasture use. There is already a project in Armenia that aims to create a pasture management information system (GIZ 2016). This is intended to improve the exchange of information between ministries, international actors and communities, to concentrate the effort of ongoing activities and thereby to enable a more efficient pasture management at national, regional and local level (ibid.). Moreover, the system aims at integrating modern methods such as remote

sensing technologies and GIS to facilitate the long-term monitoring of pastures and to enable early action to prevent degradation of grassland (ibid.).

6. Conclusions

The pasture management plan in the form of rotational grazing which was developed in both target communities of Geghadzor and Kuchak is still not properly implemented, i.e. predefined grazing times and locations as well as maximum stocking densities are often not complied with. This lacking application of sustainable pasture management practices is therefore a major reason for the still ongoing degradation of the pasture lands, resulting in a further spread of native, expansive pasture weeds. Especially, *Astragalus microcephalus*, the unknown odorous pasture weed, and various thistle species are increasingly invading the natural and valuable fodder producing areas of Kuchak and Geghadzor. Consequently, this has not only negative impacts on grassland availability and productivity, but also negatively affects livestock productivity and thus the livelihoods of the rural population in Armenia. To achieve a sustainable pasture management in both communities, improvements and investments into education and infrastructure are essential. Education can help to raise the awareness among the rural communities regarding the long-term effects of the current, unsustainable pasture management practices and to increase the willingness of the people to apply improved practices. However, improvement in infrastructure, mainly roads, watering points, machinery and agricultural buildings, are required to facilitate the access to remote pasture and to support the shift towards sustainable pasture management practices. These are still the basis for reducing or preventing the spread of expansive pasture weeds. Not only the support of the government and international organisations is required to boost a sustainable pasture management, but also more research is needed to understand why pasture user cooperatives fail to properly implement the pasture management plans. In addition, further research is needed to identify the most important expansive pasture weeds beyond doubt and to develop appropriate weed control strategies. Overall, it can be stated that cross-sectoral and interdisciplinary collaboration is fundamental to combat expansive pasture weeds, to achieve and monitor sustainable pasture use as well as to ensure biodiversity and grassland ecosystems and their service provision to the Armenian population on a long-term basis.

7. Acknowledgment

This project is a part of the DAAD-funded collaboration, GAtES (German-Armenian Network on the Advancement of Public Participation GIS for Ecosystem Services as a Means for Biodiversity Conservation and Sustainable Development), between the University of Hohenheim (UHOH) and the American University of Armenia's (AUA) Acopian Center for the Environment.

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Annex: Basic version of questionnaire

Questionnaire «Pasture Management and Pasture Weeds» – N°1

Hello, we are students from the American University of Armenia. We're conducting a research project to understand how communities in Aragatsotn marz use their pastures and if they have problems with pasture weeds. The aim of this project is to identify if and what weeds grow on pastures and how they can be controlled. We would need 30-45 minutes of your time to ask you some questions. Your answers will help us with our project.

After collecting the information and analysing the results, we hope to be back in the community in the next 6-12 months to share our findings.

General information about interview

Date:

Community:

- ☐ Geghadzor
- ☐ Kuchak

Name of facilitator(s) (first name, last name):

Name of interviewee (first name, last name):

Occupation of interviewee:

A) Seasonal grazing management

1. When does the grazing season start?
   - ☐ End of February
   - ☐ Beginning of March
   - ☐ Middle of March
   - ☐ End of March
   - ☐ Beginning of April
   - ☐ Middle of April
   - ☐ End of April
   - ☐ Beginning of May

   If any comments regarding the start of grazing season, please note down.

   _____

   _____

2. When does the grazing season end?
   - ☐ End of September
   - ☐ Beginning of October
   - ☐ Middle of October
   - ☐ End of October
   - ☐ Beginning of November
   - ☐ Middle of November
   - ☐ End of November

   If any comments regarding the end of grazing season, please note down.

   _____

   _____

3. What factors determine the grazing time per pasture?
   - ☐ Size of pasture
   - ☐ Pasture condition (availability of fodder)
   - ☐ Number of animals
   - ☐ Other factors

   If other factors, please specify. _____

   _____

4. What factors determine the number of animals going to the community pastures?
   - ☐ Available summer fodder
   - ☐ Available winter fodder
   - ☐ Money
   - ☐ Space (in barn)
   - ☐ Availability of shepherds
   - ☐ Other factors

   If other factors, please specify. _____

   _____

5. Which pastures are used more often during the entire herding season?
   - ☐ Pastures close to the community
   - ☐ Remote pastures
   - ☐ Same use of remote and close pastures

6. How is migration to remote pastures organized?
   - ☐ Animals walk
   - ☐ Transport by lorry
   - ☐ Other

   If other, please specify. _____

   _____

7. Who is responsible for herding the grazing animals?
   - ☐ Permanent shepherd(s)
   - ☐ Farmers in turn
   - ☐ Others

   If others, please specify. _____

   _____

8. Is the community pasture area enough to provide grazing animals with fodder for the entire grazing season?
   - ☐ More than enough
   - ☐ Just enough
   - ☐ Not enough

9. How has the quantity of grazing animals in the community changed in the last 10 years?
   - ☐ Increased
   - ☐ Stayed the same
   - ☐ Decreased

B) Assessment of community pastures

10. How do you asses the current condition of the community pastures?
    - ☐ Good
    - ☐ Satisfactory
    - ☐ Bad

11. How have the conditions of the community pastures changed in the last 10 years?
    - ☐ Improved
    - ☐ Stayed unchanged
    - ☐ Worsened

12. Are there degradation problems on the community pastures?
    - ☐ Not at all
    - ☐ A few problems
    - ☐ Severe problems

    12.1 If yes, what type of degradation do you observe on the community pastures?
    - ☐ Lower productivity (less fodder available)
    - ☐ Erosion
    - ☐ Spread of pasture weeds
    - ☐ Others

      If others, please specify. _____

      _____

13. Are there pastures in the community which are not used?
    - ☐ No
    - ☐ Yes

    13.1 If yes, what are the reasons that these pastures are not used?

    - ☐ Absence of water points
    - ☐ Bad quality of roads
    - ☐ Too far away
    - ☐ Daily milking procedure
    - ☐ Spread of weeds
    - ☐ Other reasons

    If other reasons, please specify. _____

    _____

14. Does the pasture quality generally increase or decrease the farther away it is from the village?
    - ☐ Increasing quality
    - ☐ Same quality
    - ☐ Decreasing quality

15. What is done in the community to maintain or improve the community pastures?
    - ☐ Nothing
    - ☐ Alternating/Rotational grazing
    - ☐ Fencing
    - ☐ Use of mineral fertilizer
    - ☐ Use of manure
    - ☐ Reseeding of grasses
    - ☐ Elimination of weed
    - ☐ Other measures

    If other measures, please specify. _____

    _____

C) Determination of existing pasture weeds

16. Pasture weeds growing on nearby pastures
    Where do pasture weeds grow on pastures close to the community?
    What pasture weed does grow here?
    When approximately have you first notice this pasture weed? (year)

17. Pasture weeds growing on remote pastures
    Where do pasture weeds grow on remote pastures?
    What pasture weed does grow here?
    When approximately have you first notice this pasture weed? (year)

18. Pasture weeds growing along cattle tracks
    Along which cattle tracks do pasture weeds grow?
    What pasture weed does grow here?
    When approximately have you first notice this pasture weed? (year)

19. Pasture weeds growing along roads
    Along which roads do pasture weeds grow?
    What pasture weed does grow here?
    When approximately have you first notice this pasture weed? (year)

20. Pasture weeds growing at other location(s)
    Where else do pasture weeds grow?
    Please describe this location.
    What pasture weed does grow here?
    When approximately have you first notice this pasture weed? (year)

21. Why do you think the pasture weeds are spreading?
    - ☐ Livestock too long on same pasture
    - ☐ Livestock not long enough on same pasture
    - ☐ Bad infrastructure to access pastures
    - ☐ Bad soil quality/Declining soil fertility
    - ☐ Climate change (getting warmer/less rainfall etc.)
    - ☐ Other reasons

    If other reasons, please specify. _____

    _____

D) Control strategies against pasture weeds

22. Do you know control measures to combat pasture weeds?
    - ☐ No
    - ☐ Yes

    22.1 If yes, what control measures do you know to combat pasture weeds?
    - ☐ Burning
    - ☐ Digging up
    - ☐ Cutting/Chopping
    - ☐ Chemical control (i.e. herbicides)
    - ☐ Biological control (i.e. insects)
    - ☐ Change in pasture management
    - ☐ Other measures

    If other measures, please specify. _____

    _____

22.1.1 How exactly did the pasture management change?

☐ Alternating/rotational grazing

☐ Fencing

☐ Reduced number of grazing animals

☐ Other changes

If other changes, please specify. _____

_____

22.2 If yes, do you carry out any of the mentioned control measures in the community?

☐ No

☐ Yes

22.2.1 If no, why do you not carry out any of the control measures in the community?

☐ Difficult to handle

☐ Labour intensive / No time to do it

☐ Expensive

☐ No effect on weeds

☐ Does not reduce weed, but rather stimulates further spread

☐ Other reasons

If other reasons, please specify. _____

_____

22.2.2 If yes, why do you carry out the control measures in the community?

☐ Easy to handle

☐ Low costs

☐ Reduced number of weeds

☐ No further spread of weeds

☐ Other reasons

If other reasons, please specify. _____

_____

22.2.3 If yes, do you use different control measures for different pasture weeds in the community?

☐ No

☐ Yes

If yes, what control measures are used for which pasture weed?

_____

_____

22.2.4 If yes, what is done with the remains of pasture weed(s)?

- ☐ Burning
- ☐ Composting
- ☐ Leaving on the ground
- ☐ Other

If other, please specify. _____

_____

_____

22.2.5 If yes, who is realising the control measures?

- ☐ Men
- ☐ Women
- ☐ Children
- ☐ Whole community
- ☐ Others

If others, please specify. _____

_____

_____

23. Do you use the pasture weeds for other purposes in the community?

- ☐ No
- ☐ Yes

If yes, how are they used? _____

_____

_____

E) Impact of pasture weeds on livestock husbandry & livelihood

24. Do the pasture weeds affect livestock husbandry in the community?

- ☐ No
- ☐ Yes

24.1 If yes, how do the pasture weeds affect livestock husbandry?

- ☐ Less area for fodder production
- ☐ Less area for grazing
- ☐ Reduced milk yield
- ☐ Less income
- ☐ Other impacts

If other impacts, please specify. _____

25. Are there any other impacts on daily life besides livestock husbandry?

_____

_____

_____

_____

F) Pasture user association and pasture management plan

26. What do you think about the pasture user cooperative?

_____

_____

_____

_____

27. Do you know if there is a pasture management plan?

☐ No
☐ Yes

27.1 If yes, do people in the community follow the pasture management plan?

☐ No
☐ Partly
☐ Yes

27.1.1 If no, why do people not follow the pasture management plan?

_____

_____

_____

_____

27.1.2 If no, what would need to change that people would follow the pasture management plan?

☐ Visible effect/benefits
☐ More fodder available
☐ Better animal productivity (milk, meat)
☐ Other

If other, please specify. _____

_____

27.1.3 If partly, why do people only partly follow the pasture management plan?

_____

27.1.4 If yes, why do people follow the pasture management plan?

_____

_____

_____

_____

G) Final questions

28. What are the most relevant problems in your community?

_____

_____

_____

_____

29. Is there anything else you find worth mentioning and we didn't talk about so far?

_____

_____

_____

_____

Thank you for participating!

Comment of the facilitator(s)

This survey was

- ☐ A test
- ☐ Finished
- ☐ Not finished

If not finished, why? _____

_____

Further comments_____

_____

_____

_____