THE ECONOMICS OF LAND DEGRADATION

The economics of pasture management in Georgia

SCIENTIFIC INTERIM REPORT

An economics of land degradation case study

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Executive summary

Longer heat waves, stronger winds and increasing demand for pasture land, are adversely affecting winter pastures in the region of Kakheti in Georgia. The resulting reduction in the biological productivity compromises food and water security and the livelihoods of pastoralist that depend on healthy land.

Currently, there are two main types of pasture use in Kakheti. The first is year-round grazing close to villages (by resident users) and the second is a migratory pastoralism with herders moving between winter pastures and highland summer pastures, used from approximately mid-May to end September. Some pasture users have leaseholds but many subleases or use the pasture with no formal legal arrangement. Within each pasture area, grazing is conducted in a continuous manner (without explicit rotations) and stocking rate sometimes exceeds the carrying capacity of the land, resulting in deteriorating pasture condition.

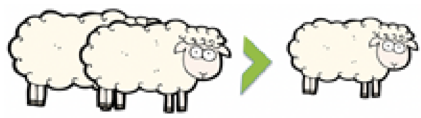
A number of sustainable pastureland management strategies may be promoted and implemented to combat land degradation. The first sustainable land management strategy consists of de-stocking under continuous grazing and managing herd sizes according to forage availability during the non-growing season. The second strategy involves planning frequent herd moves between paddocks based on vegetation around recovery periods, and the third strategy concerns annual protection periods and rotation of animals on different pasture from one year to the next. We analyse these three approaches with respect to their economic consequences on pastoral households, and impact on land productivity. Our scenarios are applied to four categories of households identified from survey data: resident pasture users (on village pasture), and small, medium and large migratory herders.

Methods

The study uses a variety of data, literature and assessment methodologies. At the outset of the study, a representative survey with over 300 pastoralists households was implemented to classify representative groups of pasture users using cluster analysis and to develop pastoral enterprise budgets of their profit, revenue and cost structures. These data were then used to determine how pasture users would be affected by changes to their herd sizes as a means to address land degradation (see SLM 1 below). Estimates of grassland dry matter productivity (from calibrated satellite imagery), were used to understand whether stocking densities were within the carrying capacity of land (see SLM 1 below). In assessing the potential case for using multi-paddock adaptive grazing systems, we relied on biomass productivity estimates and field data on forage recovery rates, from a site in Turkey with similar climate to that of winter pastures in Kakheti (see SLM 2). Finally, to understand the economics of applying annual rotations as a means to recover pasture productivity, we used experimental results from winter pastures in the Kakheti region. Improvements in forage productivity (from SLM 2 and SLM 3) were valued using household survey data. Our findings are summarized as follows for each of the SLM strategies.

Results

SLM 1: Managing herd sizes according to forage availability during the non-growing season



Using a representative household survey of pastoral households (in the winter of 2018), we

TABLE 1

Forage demand and supply in Kakheti

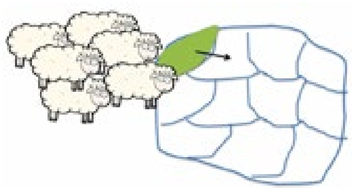
	Sustainable stocking density (SU per ha)	Current stocking density (SU per ha)	Difference
Total Kakheti	1.2	2.6	-1.4
Village pastures	1.3	3.3	-2.1
Winter pastures	1.2	2.3	-1.1

found an average stocking density of 2.6 sheep units per hectare on all pastures confounded. Holding this up against calibrated remote sensing data of pasture productivity in a year with a typical weather pattern (and no drought), we find that winter pastures can on average only support 1.2 sheep units during the non-growing season (December-February).

Given the mismatch between actual stocking density and carrying capacity of pastures (Table 1), it may be advisable for village and migrating pastoralists to de-stock. However, the economic feasibility of this attempt to tackle land degradation appears to be weak. The household survey of pasture users revealed that 50% of migrating pastoralists and 15% of residents lease pastureland. Results suggest that many of these households would barely be able to remain profitable after reducing their livestock holdings. Migratory pastoralists with small herds would go out of business. On the other hand, in the absence of pasture leasing costs results suggest that all pastoralists would be able to retain a positive net-income after destocking. Thus, a policy which aims to recover forage resources through de-stocking is likely to be more successful if leasing fees were reduced, or under tenure regimes, where resources can be pooled (such as common property regimes).

Due to lack of data from field experiments in Kakheti, we were not able to estimate how pasture productivity responds to de-stocking, but meta-analysis from Holecheck (1999) suggest that productivity may increase by 20% within 5 to 15 years following de-stocking (from heavy to moderate levels). Given this timeframe, it is unlikely that such benefits can be accounted for by pasture users in the presence of insecure land tenure and without actual evidence that "it works".

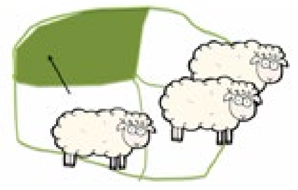
SLM 2: Multi-paddock adaptive grazing



The second SLM strategy evaluated is known as multi-paddock adaptive grazing system or 'Holistic Planned Grazing'. It calls for grazing to be planned around the recovery period of plants. Using multiple paddock system through herding or physical barriers, animals stay only a few days in any one paddock, and do not return to that paddock until the grass has recovered (Savory, 1983).

There have been no experiments of multi-paddock adaptive grazing in Kakheti to date, but we were able to use field data on biomass recovery rates from Çanakkale in Turkey, which has the same climate as that of Kakheti. Assuming a 30-day recovery period for grasses in spring and 60-day recovery period for autumn, multi-paddock adaptive grazing may allow for a 9% and 16% increase in forage resources in the first year for migrating and resident pasture users respectively, relative to business as usual. Since all pastoralists are dependent on supplementary forage purchase, the benefit of the additional forage can be valued in terms of avoided spending on hay. Doing so, we find that the annual net-benefit is in the order of 89 GEL to 136 GEL per hectare of pastureland and depending on the pasture user group (migratory or villager). Multi-paddock adaptive grazing can be adapted to any scale, small as well as large pastures, and on communal as well as privatized land, but it requires skilful use of fencing or visual herding. The effectiveness of this approach is much debated in the scientific literature, particularly in arid environments where vegetation recovery depends on erratic and seasonal rainfall.

SLM 3: Annual rotations and exclosures



Finally, sustainable rangeland management schemes may also involve much longer rotation periods - with significantly lower animal density relative to multi-paddock adaptive grazing system. Data from real exclosure experiments on winter pastures in Dedoplistskaro municipality in Kakheti (Lachashvili, 2015, 2016), show that excluding grazing for one year increases biomass by 52% for *Artemisia Lerchiana & Bothriocloa ischaemum* dominated pastures, 85% for *Artemisia Lerchiana & Salsola ericuidis* and a staggering 203% in the case of *Artemisia lerchiana* dominated pastures.

Assuming that a pastoralist places quarter of his grazing unit under protection, in that first year, he also foregoes the opportunity to graze that area. However, in the second year, he can move his animals into the newly regenerated grassland and enjoy the improved forage resources, whilst protecting yet another part of this land that was grazed in the first year (Figure 1).

However, the foregone grazing opportunity on a quarter of the pastureland implies that pastoralists grazing on *Bothriocloa ischaemum* and Salsola ericoidis pastures will experience an actual loss in total off-take by their animals, despite the overall increase in forage resources. Only pastoralists grazing on *Artemisia lerchiana* pastures, will be able to experience an increase in forage off-take as a result of the exclosures and grazing rotation measures. Valued in terms of avoided spending on forage resources, the Net Present Value benefit of adopting rotational grazing on Artemisia lerchiana pastures is in the order of GEL 26 per hectare over a 5-year period in terms of avoided forage spending. Fortunately, pastures dominated by *Artemisia lerchiana* are the most widespread pasture type on winter pastures in Kakheti (Lachashvili, 2007).

Exclosures and annual rotation also contribute to land restoration on *Artemisia Lerchiana & Salsola Ericoides* pastures. However, these measures would only be economically viable on such pastures if users are compensated fortheir contribution to land degradation neutrality.

Yearly exclosures and annual rotations on *Bothriochloa* pastures are not recommended, since this species becomes unpalatable if not grazed continuously. Village pastures in Kakheti tend to be dominated by *Bothriochloa* (see section 2.4) and therefore may not be suitable for this SLM approach.

FIGURE 1

Annual rotational grazing plot

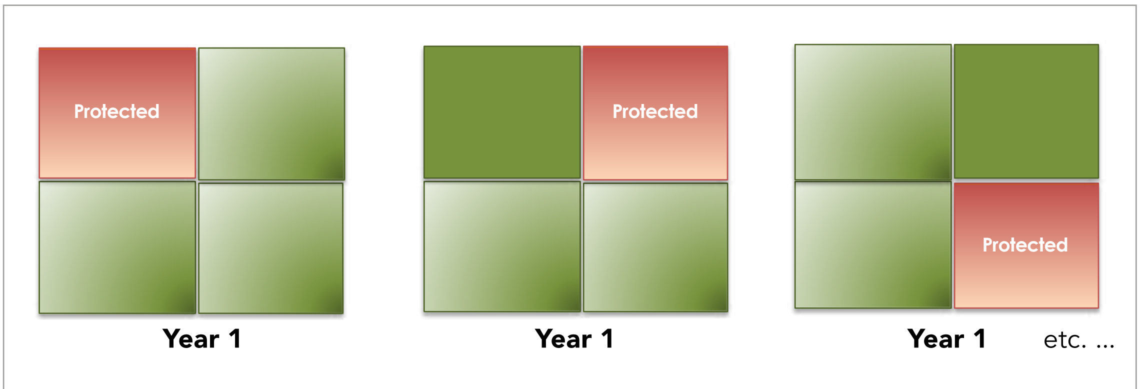
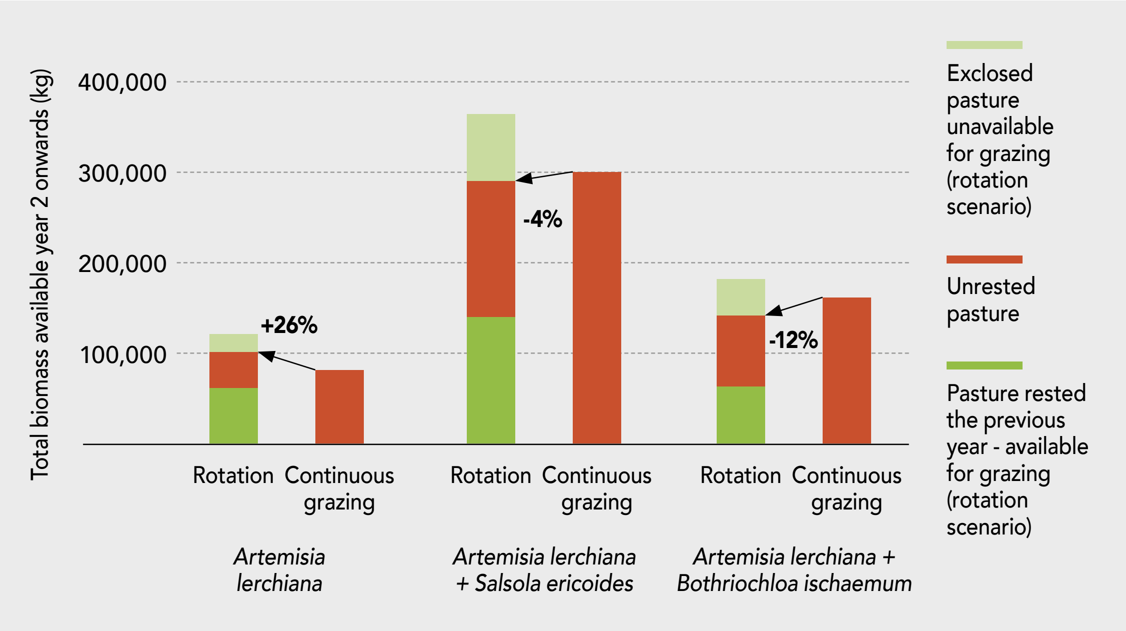


FIGURE 2

Comparison of available biomass under rotation and continuous grazing on three vegetation types for migratory households with small herds.

(Percentages indicate the change in biomass in year 2 when the rotation scenario is implemented)



On the whole, literature and experimental results show that all of the three rangeland management strategies evaluated; continuous grazing and de-stocking, multi-paddock adaptive grazing and annual rotations, will result in improved forage productivity (see Table 2) relative to Business As Usual (BAU) which is characterized as continuous grazing on winter pastures above the carrying capacity of the land.

Land productivity is one of the three main indicators to measure progress towards Land Degradation Neutrality (LDN). Therefore, with these three strategies at hand, pastoralists have a set of tools and grazing management principles that each can contribute to LDN, either in isolation or in combination to one another, from any one year to another.

TABLE 2

Summary of land productivity from SLM scenarios

SLM interventions	Change in forage productivity	Time-frame	Source	NPV/ha from adoption SLM
De-stocking from heavy grazing to moderate grazing	Regeneration of up to 20%	Within 5-15 years	Holecheck (1999)	N/A
Multi-paddock adaptive grazing / migrator	9%	Within 1 year	Own calculation	89 GEL/ha
Multi-paddock adaptive grazing / resident	16%	Within 1 year	Own calculation	165 GEL/ha
Annual rotational grazing	13%-51%	Within 1 year	NACRES + own calculation	from - 59 GEL/ha to +26 GEL/ha

The land productivity improvements shown here should not be viewed as fixed. Semi-arid rangeland environments are highly variable, so pasture health may change from year to year, season to season, and location to location.

For this reason, it is not recommendable to advise on a fixed stocking density, because optimal stocking densities will vary in space and time. The resulting policy recommendation is rather one of making sure that pastoral communities are equipped with the tools and knowledge to estimate and monitor forage resources, discern vegetation type, adjust grazing patterns, recovery periods and/or stocking rates accordingly (SLM 1/2/3) and finally, to understand the advantages, costs and risks of each rangeland management method.

Policy implications and recommendations

It should be stressed that the above findings, are based on locally untested assumptions, particularly those of vegetation recovery in the multi-paddock adaptive grazing scenario. To allow for improved learning at household, community and national level, each of the SLM strategies evaluated here would benefit from actual field-testing and demonstration on winter and village pastures in Kakheti. Pastoralists participating in such trials and field-testing schemes could furthermore serve as representatives in local initiative groups that would work in coordination with competent institutions to facilitate LDN target setting and produce LDN monitoring results (Huber et al. 2017).

In order for this to happen, pastoralists will need to have the legal disposition to benefit from their sustainable land investments, which implies reforms in overarching policy and the land tenure framework. For example, the pasture leasing process (currently subject to a temporary moratorium) is held by electronic auction at the national level, with pasture provided to the highest bidder regardless of their residency and actual use of the pastures in question. This process is inaccessible to most livestock owners and explains why so many subleases. Village pastures are de facto commonly managed, as herds are comprised of animals belonging to multiple owners who manage grazing as a group. The lack of legal instruments to delimit and designate municipal pastures to village users for common use is both a source of insecurity for village-based livestock owners and a barrier to good management. The outcome of this situation is that the vast majority of livestock owners in Georgia do not have formal access (whether ownership, leasehold or defined common use rights) over pastures.

Overall, Georgia should therefore consider designing new land tenure legislation specific to pastures, which recognises the specific ways in which pastures are actually used and managed. Where use is organised on a collective basis then the law could reflect this in forms of common property resource management (CPRM), at the appropriate spatial scale. Where leaseholds are more appropriate, mechanisms

administered locally, and which prioritise access by actual users - as currently piloted in Akhmeta district - should be further explored. Decentralisation of pasture administration to municipalities and its inclusion into new spatial planning procedures is one pathway to improved pastoral tenure arrangements.

01 Introduction

Natural pastures cover 1.9 million hectares or around 25% of Georgia's area. Kakheti is the foremost pastoral region (GeoStat 2016), with an estimated 75% of the national sheep population wintering in the region – and 40% in Dedoplistskaro Municipality alone. As such, the pastoral system in Kakheti is largely nomadic, with migrating pastoralists using high summer pastures in Akhmeta district and wintering in the southern lowlands (UNDP, 2014).

However, winter pasture availability has shrunk due to loss of access to winter pastures in Azerbaijan and Dagestan with the end of the Soviet Union. Coupled with growing export demand for sheep, this has led to increased stocking densities and pressure on the land, often by individuals with no former experience in farming (Phularian 2018, personal communication).

Because of unsustainable use of pastures and forests, as well as climate change and lack of knowledge about sustainable land management, the second National Action Programme of Georgia (Government Decree #742) identified Kakheti as one of the region's most vulnerable to desertification and land degradation. Land degradation compromises food and water security and disaster risk management – hindering the prospect of achieving the Sustainable Development Goals by 2030 and specifically goal 15, target 15.3, which calls for the achievement of land degradation neutrality.

POLICY FRAMEWORK

In this context, the ELD approach (ELD Initiative 2015) is used to propose feasible sustainable pasture management interventions and to assess the costs and benefits of their adoption. Building on Huber et al. (2017) and Robinson (2018), the assessment also considers how these interventions can contribute to Land Degradation Neutrality and how best to facilitate the uptake of these interventions, through the reform of overarching policy and land tenure frameworks (Chapter 7).

Such reforms are crucial, as the existing legal and institutional environment is not conducive to sustainable management of pastures. For example, there is currently a moratorium on leases of state-owned pastures that until recently were allocated though an electronic auction system, with land provided to the highest bidder regardless of actual use of pastures. This has led to unequal access to land and speculation, with leaseholders often subleasing to those pastoralists unable to participate in the online auctioning system. The short length of many leases discourages investment in the long- term health of pasture resources. Furthermore, because pastoralism is associated with economies of scale (Chapter 4), high leasing costs makes it economically unfeasible for migrating pasture users to adopt certain sustainable land management approaches.

At yet another level, village pastures are de facto managed in common, as these areas are used by entire communities and grazed by herds made up of stock belonging to multiple owners. Animals graze on crop residue following harvests in autumn, and hereafter use public lands, including roadsides, windbreaks, secondary forests and shrublands. The formal designation of village pastures would facilitate their management and relieve pressure on these habitats. But municipalities lack legal instruments to delimit municipal pastures to village users for common use. This is a source of insecurity for village-based livestock owners and a barrier to structured management. Whilst some municipalities own pasture in their own right, it is estimated that this pasture makes up only 2% of the total and the legal possibility to register municipal pasture is no longer available (Robinson 2018).

Where use is organised on a collective basis, then arguably the law should reflect this in forms of common property resource management (CPRM). Where individualization of pastures and leasehold may continue to be appropriate, various measures can be employed, to incentivize sustainable land management, for example by amending the conditions for access to pasture lease and sub-leasing; rewarding pastoralists for engaging in the regeneration of pastureland through modulable pasture lease fees (the level of which could depend on engagement in SLM pilot schemes or participation in training and capacity building). These measures and associated land tenure frameworks are discussed in the final chapter of this report, drawing on the technical analysis of the economic case for adopting sustainable land management.

VALUING SUSTAINABLE LAND MANAGEMENT

In Kakheti, Business As Usual, is associated with seasonal and year-long continuous grazing for migrating and resident pastoralists. In continuous grazing systems, degradation of pastures can be addressed by balancing forage demand with forage production. When offtake exceeds that allowing sustainable forage supply, there is a case for decreasing stocking densities. In the first SLM intervention valued in this report, we therefore consider whether there is a case for adjusting stocking densities on winter and village pastures in Kakheti and assess the economic impacts of de-stocking on pastoral household economies during the non-growing season, when pastures are most vulnerable to overgrazing.

Other approaches to sustainable grazing management incorporate grassland recovery periods through the use of paddocks. These may range from a few days up to year-long protection, under annual rotation schemes. Resulting changes in duration and intensity of grazing impact the sustainability and profitability of rangelands (Sampson, 1923).

Whilst rotational grazing systems have been widely recommended by government agencies concerned with rangeland degradation, in arid and semi-arid environments the evidence that they are superior to continuous grazing is weak or absent (Briske et al. 2008, Hawkins et al. 2017, Holechek et al. 1999). On the other hand, some types of rotation do produce positive results and these approaches are valued by many livestock owners and range managers (Budd and Thorpe 2009, Teague et al. 2013). In this light it is opportune to value the potential contribution of rotational grazing schemes to pastureland restoration in Georgia. For this purpose, we consider a simple annual rotational grazing scheme and a multi-paddock adaptive grazing management scheme, used in Holistic Planned Grazing (Savory Institute 2018), which explicitly considers the recovery period of vegetation.

For the multi-paddock intervention, we parameterize our model with recovery rates from field stations in Turkey with similar climate to Kakheti, whereas the annual rotational grazing model uses experimental data from winter pastures in Vashlovani National Park in Georgia. These inputs are used to model changes in land productivity and the benefits of this to pastoral households.

The scope of this valuation exercise is constrained by the available data. The impact of the first SLM intervention is valued in terms of how household incomes are impacted by changes in stocking densities. We assess the impact of rotational grazing and multi-paddock grazing on the basis of the value of additional forage resources that are generated.

Finally, benefits from the recovery and improved productivity of pastures can only be realised once appropriate property rights frameworks are designed at the national level and pastoralists have secure land tenure. In particular, land use planning and management capacities at the local level are necessary to move beyond the status quo and create the necessary incentives for pastoralists to plan, invest and manage pastures sustainability.

In the next chapter, we present the case-study area, its characteristics and evidence of land degradation on winter pastures. Chapter 3 discusses different approaches to sustainable land management (SLM), whilst in chapters 4,5 and 6 we value three distinct interventions and assess their impact on pastoral livelihoods and land productivity. In Chapter 7, we present existing policy frameworks and land tenure legislation that can provide the enabling foundation for Georgia to meet its Land Degradation Neutrality targets. Chapter 8 concludes.

CHAPTER

02 Case-study area and land productivity

2.1 Kakheti and its municipalities

Kakheti is located in eastern Georgia (Figure 3). The region has the largest area of arable land, permanent cropping and pasture or meadow in Georgia. It is host to 40% of all agricultural holdings, whilst an estimated 65% of the sheep and goats owned in Georgia are based there (GeoStat 2016).

The ELD household survey and biophysical data collection that has informed this study took place in five of Kakheti's nine municipalities (Dedoplistskaro, Gurjaani, Telavi, Akhmeta and Sagarejo). Figure 3b indicates the location of the municipalities and the sampling points for the survey.

The municipality of Dedoplistskaro is one of the largest in Kakheti and considered to be the primary region of lowland pastoralism in Georgia. Winter pastures occupy 52% of its total area (UNDP 2014) and the Dedoplistskaro steppe is thus home to large numbers of wintering livestock, with over 40% of sheep in Georgia using winter pastures in the municipality (Gonashvili et al. 2013). There is an estimated 65,189 ha of pasture in Dedoplistskaro municipality and 37% of all agricultural land is used for hay and pasture (GeoStat 2016).

The winter pastures of the Vashlovani protected area are located at the south-east end of the mu-

FIGURE 3

The region of Kakheti and its pastures

Figure 3a: The region of Kakheti in eastern Georgia.

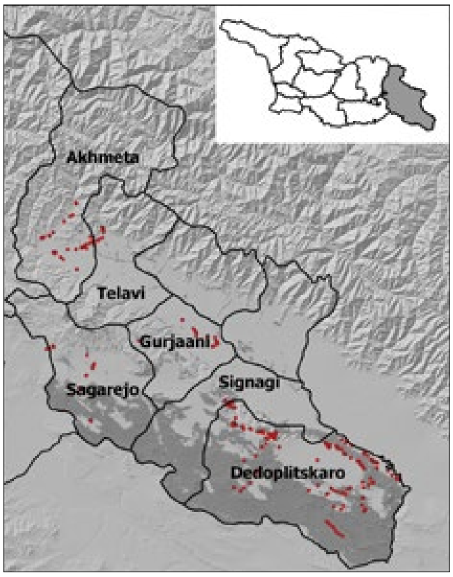
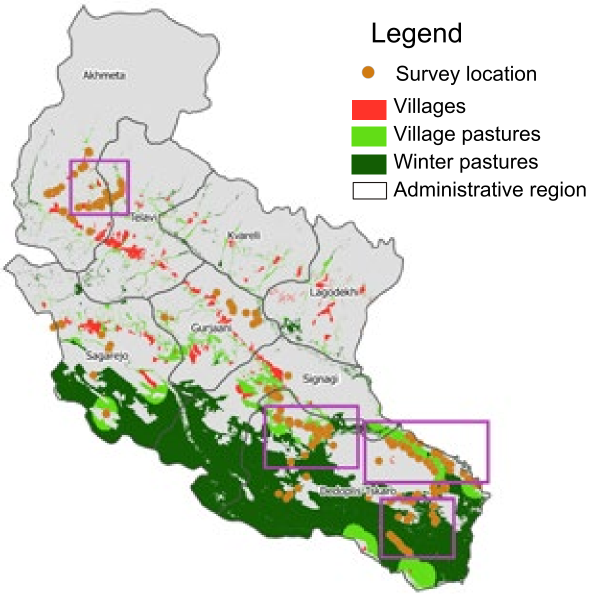


Figure 3b. Winter pastures (<1800 m) in Kakheti as defined from satellite imagery and elevation



nicipality. Data from Vashlovani has been used to evaluate annual rotational grazing schemes (Chapter 5). Dedoplistskaro is bordered by Azerbaijan to the south, east and north-east. There are large populations of Azeri households in the municipality who use the unmanaged grasslands for their livestock. These nomadic households do not have the right to buy or rent Georgian farmland.

Sagarejo also hosts important wintering areas (Gonashvili et al., 2013). Gurjaani and Telavi are traversed by migratory routes connecting the summer pastures of Tusheti protected area and wintering pastures in Sagarejo, Dedoplistskaro and Vashlovani protected areas (Gonashvili et al. 2013, Mansour 2016). The summer pastures of Tusheti protected area are located in the north of Akhmeta and there is high population of Tush shepherds (Gogotidze 2018). Nomadic pastoralism is practiced in all of the municipalities.

2.2 Definition of summer, winter and village pastures in Kakheti

At the outset of this study, at the inception workshop in Tbilisi in March 2018, it was agreed that the 'winter' and village pastures in lowland areas of Kakheti were the highest priority for this study, since most research projects have concentrated on summer and mountainous pastures in protected areas and national parks such as Tusheti (ELKANA 2014, GIZ 2013, NACRES 2013).

Winter pastures are located less than 1700m above sea level and are used both by transhumant households and local village residents. When used by transhumance pastoralists, these are referred to winter pastures, and when used by villagers, they are referred to village pastures. According to Raaflaub and Dobry (2015), transhumance pastoralists account for about 75% of livestock in Georgia and the total estimated area of winter pastures in the country is 300'000 ha.

Winter pastures are often privately leased (see below). According to the survey undertaken for this study, 50% of the transhumance households either own or lease winter pastures. To the outside observer, leasehold boundaries are not visible due to the absence of fencing. As argued by Raaflaub & Dobry (2015), winter pastures are also governed by self-regulation among local and nomadic pasture users. This typically means that shepherds are free to lead their herds to locations with best grass growth, coordinating herd movements and pasturing areas informally among themselves.

Village pastures include unfenced land in and around settlements. Cows are left to freely graze these areas during the daytime. Sometimes, a shepherd is responsible to guard the cows and leads them towards the areas with best forage (Raaflaub and Dobry 2015). In general, however, village pastures in Kakheti are in short supply. Moreover, privately owned fields are rarely used for pastoral activities exclusively[1], as cropping is more profitable (Mekhtieva 2018, personal communication). This implies that villagers often use various fragile public lands such as windbreaks, scrublands and secondary forests for grazing (Arabuli 2018, personal communication).

Summer pastures are located from 1700 to 2800 m above sea level, where there is a cooler climate, higher rainfall and naturally richer pasture during summer. Summer pastures are mostly used by transhumant shepherds and a small population of residents. Access difficulties reduce grazing pressure there in the winter.

2.3 Property rights arrangements on pasture

The legacy of past reforms has left Georgia with both privately and government owned pastures, the latter administered by the Agency for State Property (ASP), municipalities, and the Agency for Protected Areas (APA).

Pasture privatisation (into full ownership). Although previous laws enabled privatisation of state pasturelands, under the current 2010 Law on State Property, pasture and cattle trails cannot not be privatised. There are two exceptions to this. Firstly, pasture land leased before 2005 may be privatised by direct sale. Secondly, pasture can be privatised if it can be re-designated as another type of agricultural land, on which privatisation is permitted. This type of registration into private ownership continues to some (unknown) extent and this process is conducted by national auction, open to all citizens of Geor-

[1] For the most part, they are used as arable fields, grazed after harvest.

gia. For unleased lands there also remains a second direct sale option by which large investors may apply to the Georgian Government directly for land, based on business plans, with or without competition.

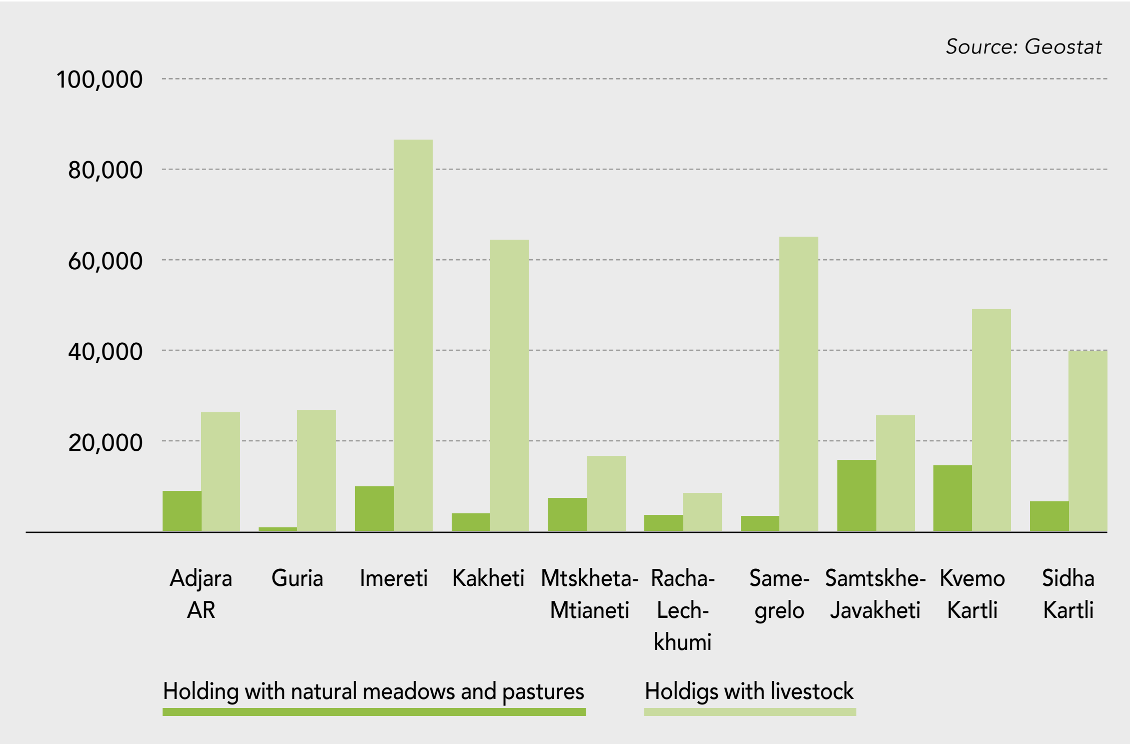
Pasture leaseholds. The main legal pathway to pasture access is the 49-year leasehold which, outside protected areas, is administered by the ASP. The leasing process is held by electronic auction at the national level, with parcels awarded regardless of the residency or actual use of the pastures in question by the applicant. This process is inaccessible to most livestock owners. In some cases, leaseholders do not even own livestock and sublease to others for short periods. Although there are many leaseholders on winter pastures, these leases date from earlier legal arrangements and few new contracts have been issued since 2010 due to bureaucratic barriers associated with the auction process and the price of leasehold, which is said to be extremely high (ELKANA 2014, Robinson 2018)[2]. In 2018 there was a moratorium on leasehold issuance whilst the ASP conducted an inventory of state agricultural lands. The APA administers leaseholds in protected areas and the process of leasehold allocation may be different - the APA has the ability to issue its own leasehold contracts with specific terms and conditions for the protected area.

Many village pastures are de facto commonly managed, as herds are comprised of animals belonging to multiple owners who manage grazing as a group. But these pastures have no legal status as such and the only legal protection from individual leasing is the possible veto on ASP-administered leasehold agreements by the local municipality. The lack of legal instruments to delimit and designate municipal pastures to village users for common use is both a source of insecurity for village-based livestock owners and a barrier to good management. Whilst some municipalities own pasture in their own right (registered under laws in place from 2005-2010), it is estimated that this pasture makes up only a small proportion of the total, and legal mechanisms to register additional pastures in this way no longer exist.

The outcome of the above-described situation is that the vast majority of livestock owners in Georgia, and in Kakheti, do not have formal access (ownership or leasehold) over pastures (Figure 4).

FIGURE 4

Agricultural holdings with livestock and formal access to pastures and meadows



[1] *The minimum price of GEL 15 per hectare must be added to local land taxes which are of a similar order, leading to per hectare prices at a minimum of 30 GEL or €10 equivalent. Given that livestock raisers must typically lease several hundred hectares of pasture, this is considered to be very high relative to typical profits from extensive livestock raising and is a particular burden for those subleasing, who must therefore pay much more than this amount (ELKANA 2014).*

2.4 Species composition of pastures

The vegetation of winter pastures in Kakheti is dominated by plant communities of xerophilous dwarf shrubs and semi-shrubs such as *Artemisia lerchiana, Artemisia lerchiana - Salsola ericoidis,* and *Artemisia lerchiana - Bothriochloa ischaemum* communities, typical of semi-arid pastureland. The most widespread of these are communities dominated by *Artemisia lerchiana*, an excellent fodder plant on winter pastures and the main food for wintering sheep (NACRES 2013). The productivity of Artemisia is higher in autumn than in winter and early spring, and from April it decreases considerably. The other fractions (grasses, legumes, forbs) maintain almost equal biomass in autumn and winter but from early spring (February-March) their productivity increases, reaching a maximum in April. Therefore, in the period when productivity of *Artemisia* is decreased, the proportion of the other fractions increases.

As for the vegetation types of winter pastures, the map of Kiziki/Dedoplistskaro (Figure 5) shows that desert vegetation, characterized by *Artemisia lerchiana* and *Salsola ericoidis*, can be found on the winter pastures in the southern part of Dedoplistskaro. According to Lachashvili et al. (2007), Artemisia- dominated pastures are the most widespread whilst *Artemesia-Salsola ericoidis* communities are relatively restricted, mostly located in the central part of the Eldari lowland. *Bothriochloeta* comprises the entire area of steppe distribution and is characteristic of village pastures. These data are used to inform the rotational grazing valuation scenario.

2.5 Climate and pastureland productivity

Kakheti as a whole has a warm temperate humid climate with hot summers (Kottek et al. 2006) and an average annual temperature of 10°C (Bolashvili et al. 2018).

Figure 6 shows the monthly variability of temperature between 1948-2017, using box plots. The dashed purple line shows the average temperature for 2017, the most recent year for which

FIGURE 5

Vegetation map of Dedoplistskaro *Source: Lachashvili et al. (2007)*

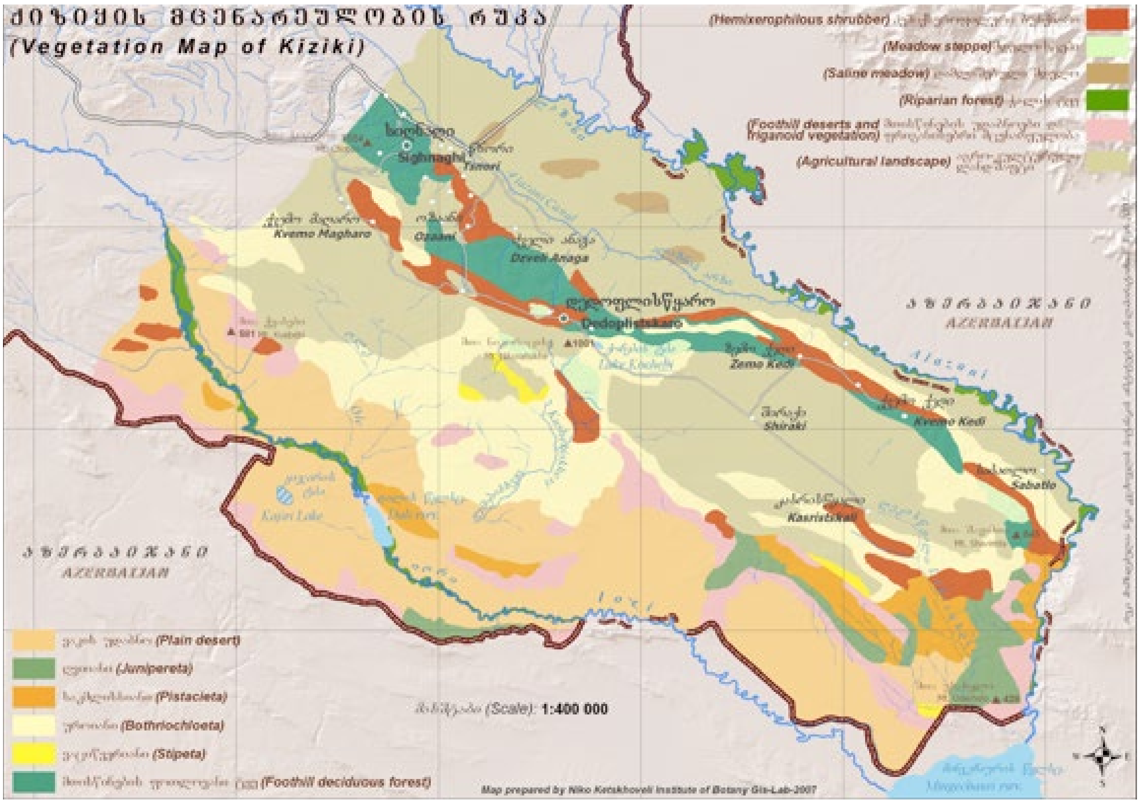


FIGURE 6

Agricultural holdings with livestock and formal access to pastures and meadows[3]

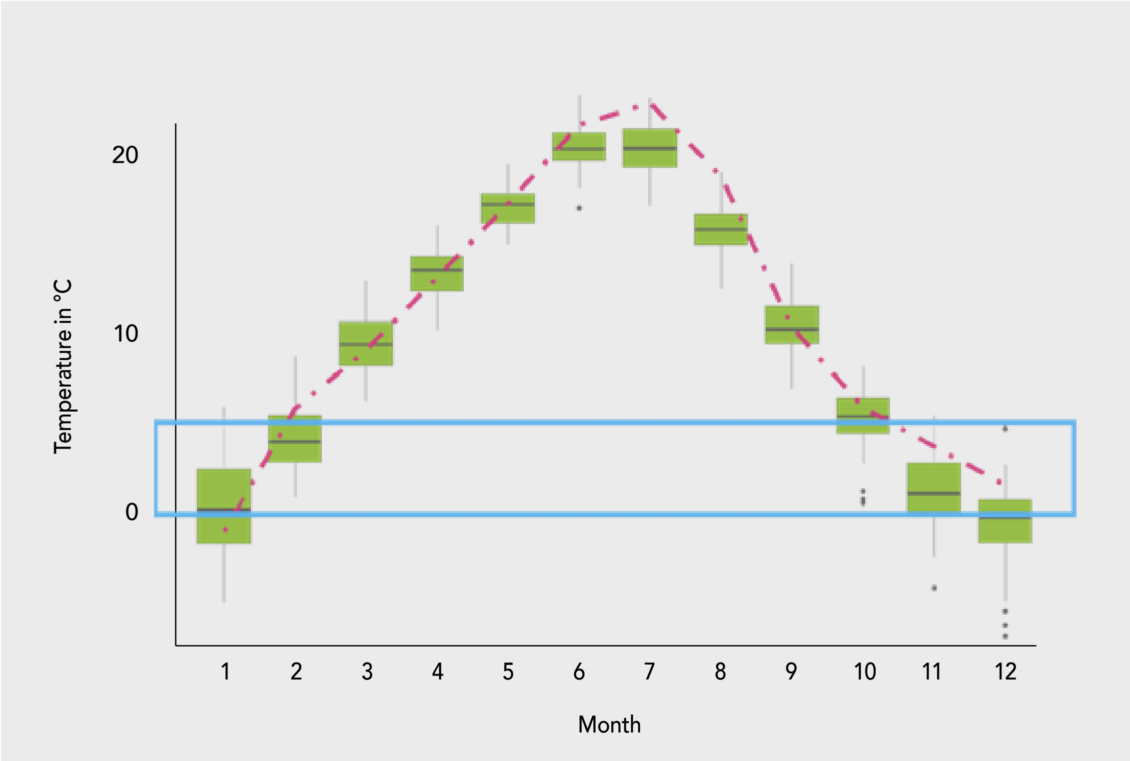
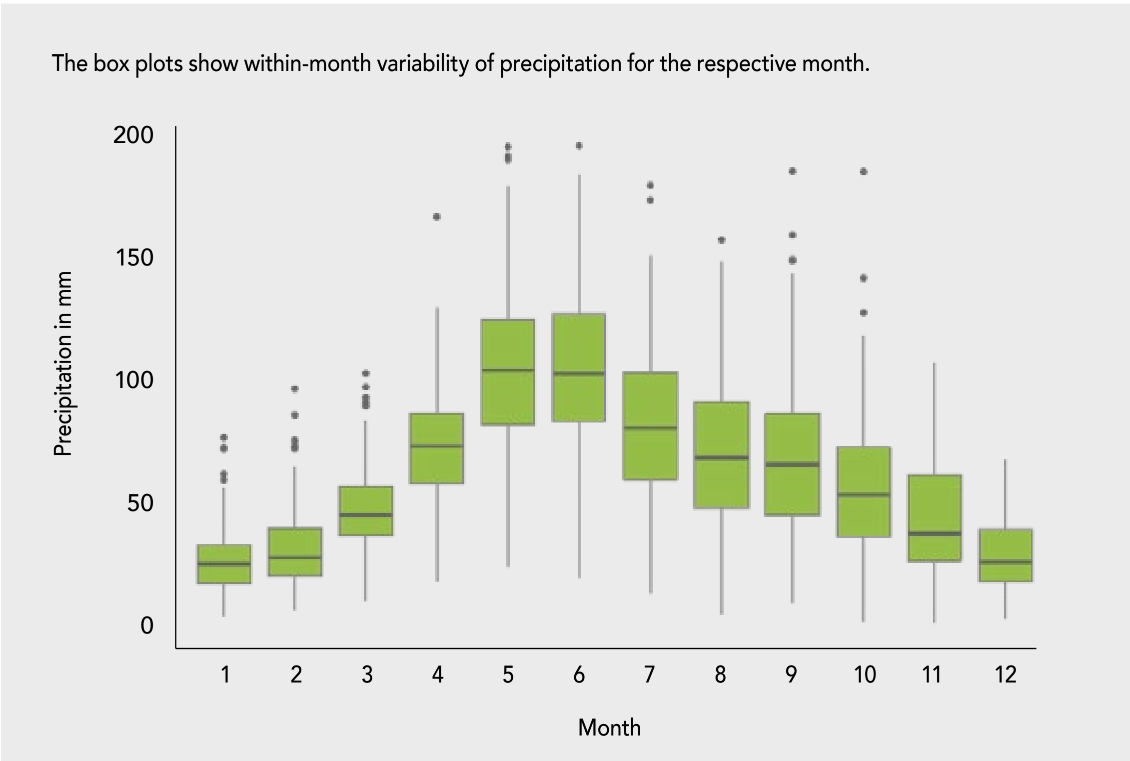


FIGURE 7

Monthly mean precipitation for Kakheti between 1948 and 2013[4]



[3] Own calculation based on GHCN Gridded V2 data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA.

[4] Own calculations based on Schneider, Udo; Becker, Andreas; Finger, Peter; Meyer-Christoffer, Anja; Rudolf, Bruno; Ziese, Markus (2015): GPCC Full Data Reanalysis Version 7.0 at 0.5°: Monthly Land-Surface Precipitation from Rain-Gauges built on GTS-based and Historic Data. DOI: 10.5676/DWD_GPCC/FD_M_V7_050.

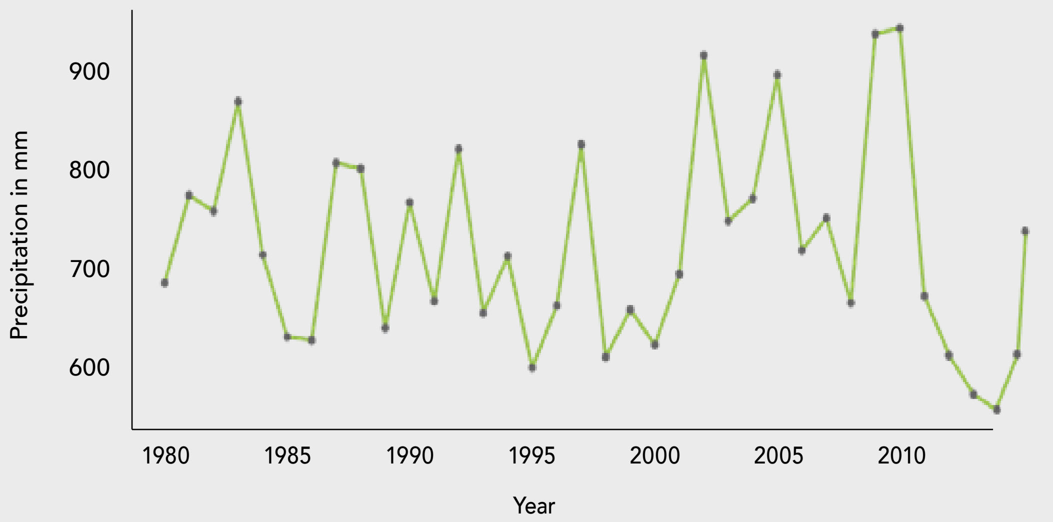
FIGURE 8

Annual mean temperature in the region of Kakheti

we have a complete dataset. Low growth rates for grassland (blue box in Figure 6) are found at temperatures between 0° and 5°C - from approximately October to February - with a strong increase at temperatures above 5°C (Nagelmüller et al. 2016). Peak growth occurs in late spring and early summer, falling off in late summer and autumn is restricted as temperature and solar radiation decrease (Hurtado-Uria et al. 2013). Dedoplistskaro and Sagarejo municipalities have an overall annual precipitation level of 500-700 mm (Bolashvili et al. 2018), but winter pasture areas are semi-arid, with lower annual rainfall (between 250mm and 500mm in Dedoplitskaro). Telavi, Akhmeta and Gurjaani have a slightly higher average of 700-900 mm (Bolashvili et al. 2018). For Kakheti, monthly precipitation records show pronounced within-month variability, particu-

FIGURE 9

Annual precipitation in the region of Kakheti



larly from May to October. Monthly precipitation rarely exceeds 150 mm in the summer and 50 mm in the winter months (Figure 7). Since temperature, precipitation and solar radiation have a strong influence on the productivity of pastures (Bernhardt-Römermann et al. 2011, Jiao et al. 2017) aboveground net primary productivity of grasslands is highly seasonal in Kakheti.

Concerning historical trends, the climate in Kakheti has become warmer over the last few decades (Figure 8), with recent years being particularly dry (Figure 9).

2.6 Evidence of land degradation in Kakheti – Literature

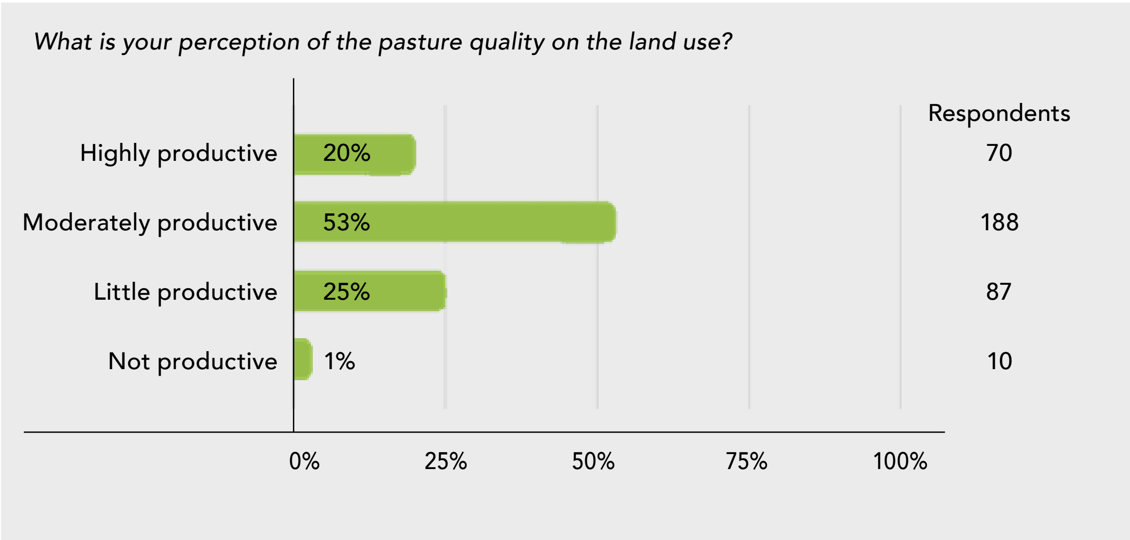
The UNCCD defines land degradation as "the reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes arising from human activities" (UNCCD Knowledge Hub 2020b). In Georgia's second National Communication (SNC) to the UNFCCC, land degradation is considered one of the most acute problems affecting pastures and arable lands in Dedoplistskaro, manifested as a decrease in the depth of humus on agricultural land due to wind erosion (Mansour 2016). Furthermore, the Third national Communication of Georgia to the UNCCD suggested that intensified and more frequent precipitation in Kakheti is causing soil erosion on mountain slopes, which, against the background of extensive exploitation of grass cover, has been accompanied by a dramatic decrease of productivity of haylands and pastures (UNDP 2014).

It is also worth noting that in Dedoplistskaro, temperatures in summer have increased by +3 degrees, and the number of extremely hot days per year by 16 days, leading to increased incidence of drought. The hay harvest depends on summer precipitation, which has decreased by 22% against a background of increase in total annual precipitation (UNDP 2014).

Although climate change appears to be negatively affecting pasture productivity, there is little evidence in the current literature of widespread overgrazing in Kakheti, except locally along transhumance routes and around summer encampments (Government of Georgia 2015). In Vashlovani national park (VNP), only 20% of pastures are classified as having poor productivity despite heavy grazing in some areas, whilst around 47% are characterized as excellent (NACRES 2013). It has also been argued that some pastures in VNP, notably those dominated by Bothriochloeta, are undergrazed (Gintzburger 2012). However, the situation may be different outside the park, where we have anecdotal

FIGURE 10

Perception of pasture quality *(Source: ELD 2018 pastoral household survey)*



evidence that the landscape is "full-up", that is, there is no unutilized land (Robinson 2018).

In the regions of Kvemo Kartli and Samtskhe-Javakheti (in the southern part of Georgia), Jarman et al. (2011) also found little evidence of overgrazing, but some evidence of declining pasture quality due to increasing aridity, particularly in lowland areas and at the end of summer. Areas at higher altitude appeared to be less affected by climatic change. It is recommended that a similar assessment using a combination of field data and relatively high-resolution satellite imagery (Landsat in this case) should be conducted for Kakheti.

2.7 Evidence of pastureland degradation in Kakheti – primary research

2.7.1 Perception amongst pasture users

Investigating the perception of pasture user themselves, the household survey undertaken for this study shows that 25% of pastoralists consider them to be poorly productive (Figure 10). Of these, 24% consider the reason to be lack of grazing control. The remainder pointed to natural factors and lack of water or irrigation. Of those considering pastures to be moderately or highly productive, 94% attributed this to "nature" and 1% only to grazing control. Finally, concerning perception of the main environmental problems on pastures, drought is considered to be the main issue and only 13% pointed to overgrazing (Figure 9).

The results suggest that among pastoralists themselves there is not a widespread perception that pastures are degraded, nor that overgrazing causes degradation.

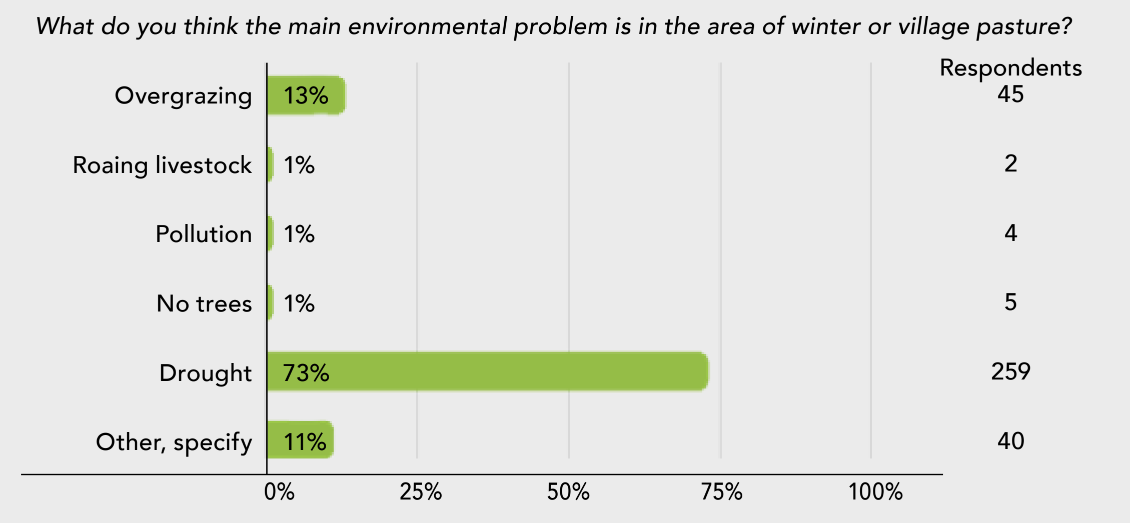
2.8 Perception of pasture quality

The normalized difference vegetation index (NDVI) can be used as an indicator of vegetation health, because degradation of ecosystem vegetation, or a decrease in greenness, is reflected in a decrease in NDVI value. Figure 12 shows mean NDVI values observed in the grasslands of Dedoplistskaro (light orange in Figure 5) for June and October between the years of 2002 and 2018. The NDVI data is sourced from the Institute of Surveying, Remote Sensing and Land Information (IVFL) of the University of Natural Resources and Applied Life Sciences (BOKU), Vienna. Data is provided as smoothed MODIS NDVI 16-Day raster time series with a resolution of 250m.[5] A linear trend is fitted to the time series of each of the two months examined.

The monthly series are characterized by substantial year-to-year variability, which reflects the patterns of year-to-year precipitation in the selected months. Significant trends are there-

FIGURE 11

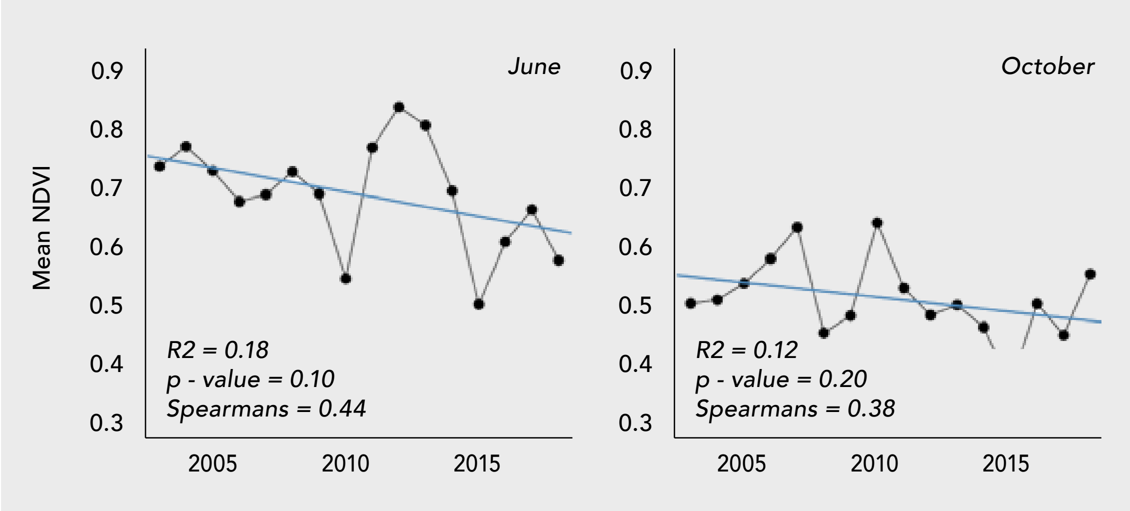
Perception of environmental problems on pastures *(Source: ELD 2018 pastoral household survey)*



[5] Available from: http://ivfl-info.boku.ac.at/satellite-data-processing/dataprocess-global

FIGURE 12

Evolution of mean NDVI over the grasslands of Dedoplistskaro for the months of June (left) and October (right) between the years 2002-2015.

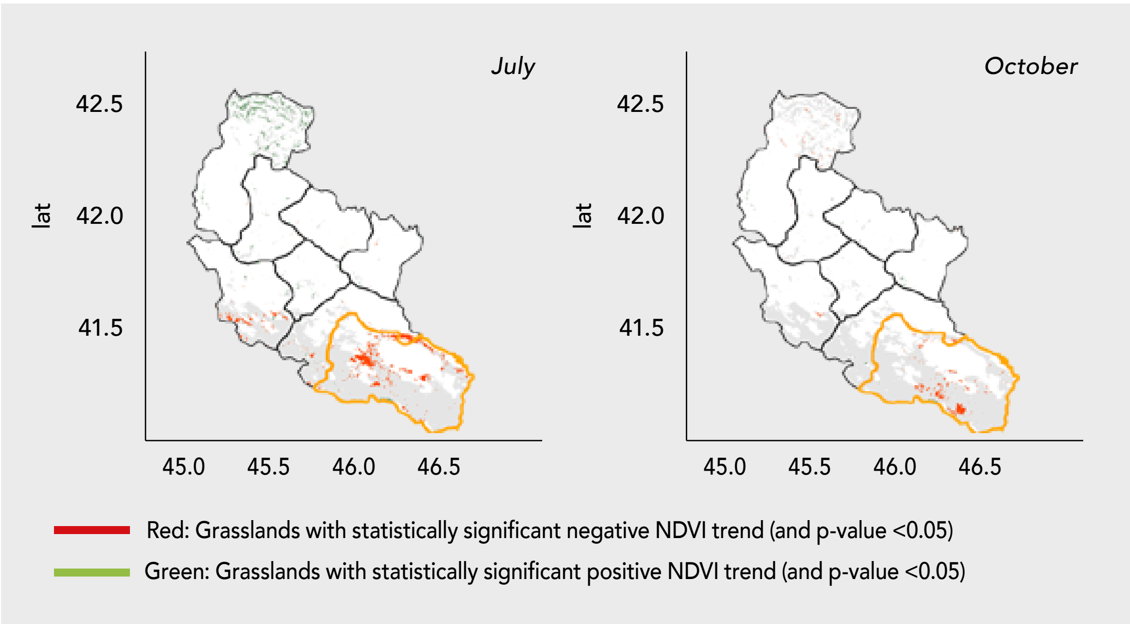


fore difficult to detect. This is reflected in the low values of R2 and high p-values depicted. When employing the Spearman's rank coefficient, a measure of the statistical dependence between the rankings of two variables, both tests return values below zero, implying a negative association between the two variables. Ultimately, the low R2, high p-value and mild negative Spearman's coefficient, do not allow for a clear statement on the overall direction (degradation/no-change/improvement) of the grassland conditions in Dedoplistskaro.

However, because we are averaging over all grassland areas in Dedoplistskaro, localized negative trends might be masked by improvements in other locations. Accordingly, the results for Dedoplistskaro need to be contextualized with the

FIGURE 13

NDVI trends for July and October in Dedoplistskaro



spatial trends observed. Figure 13 indicates the spatial distribution and strength of the observed changes, using the same principle described above, but with the analysis done at the pixel level. The red areas highlight the locations in which the trends in NDVI recorded are negative and, simultaneously, the p-value of those trends is below 0.05. This provides clear evidence of land degradation in localized areas in Dedoplistskaro.

2.9 Monitoring of land degradation

Land degradation neutrality (LDN) implies no net loss of land-based natural capital relative to a baseline, requiring that anticipated losses are counterbalanced with measures to achieve equivalent gains. Counterbalancing should occur only within individual land types, implying that any degradation of rangelands should be offset by measures aimed at avoiding, halting or restoring the degradation of rangelands (Cowie et al. 2018).

The UNCCD Science Policy Interface recommends that the monitoring of Georgia's Land Degradation Neutrality status is conducted using the three UNCCD land-based global indicators, namely:

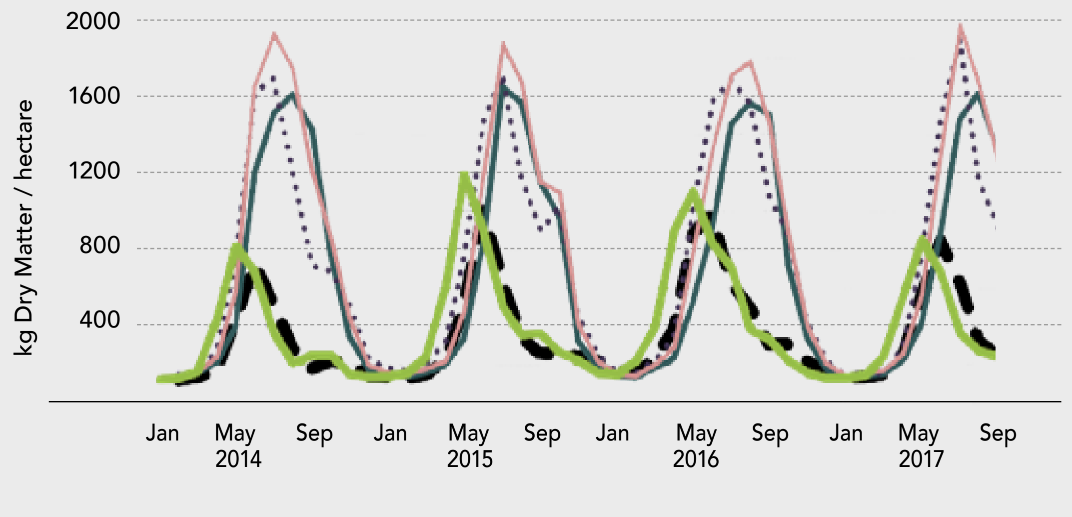
- Physical land cover classes (land cover);
- soil organic carbon (carbon stocks);
- net primary productivity (land productivity).

If any of these three indicators show significant negative change, this indicates that degradation is happening (Huber et al. 2017). Through a consultative process amongst RECC, GIZ (SV BoDeN and IBIS) and the CCD focal point, it was established that in Georgia, priority areas include the national capacity to monitor and to map change in land cover classes; the quality of forests, pastures and arable land, and in the productivity of agricultural areas, forests and pasture. In this study, we focus primarily on pastureland productivity, because of its link to household economy as the main provisioning ecosystem service that pastoral households depend upon. The starting point detection changes in primary productivity is the setting of an LDN baseline.

As argued in Appendix 1, 2016 is a good candidate year for the primary productivity baseline, because it can be considered a "representative year" weather-wise, in that precipitation and temperature patterns (the main factors limiting grassland productivity) can be considered close to long term averages. Year 2016 was identified,

FIGURE 14

Primary productivity of winter pastures in kg dry matter per hectare, 2014- 2017



Based on the Leaf Area Index from PROBA-V data calibrated to biomass using field data (see Appendix 2)

at the outset of this study, before information became available on the likely candidates for the LDN baselines. According to Ghambasidze (Oct 2018, personal communication), the LDN baseline year is 2015 for SOC and land cover change is to be measured from 2000-2015.

2.10 Primary productivity of winter pastures in Dedoplistskaro - baseline

The productive capacity of land has been measured using a remotely sensed proxy called the Leaf Area Index (LAI) which was calibrated to biomass using field measurements undertaken by the E.C.O. institute in Tusheti (Kirchmeir 2018) using methods described in Appendix 2. Figure 14 shows biomass estimates in dry matter per ha (DM/ha) from 2014 to 2017 for winter pastures in the five municipalities where the survey was undertaken - highlighted in dark green in Figure 3b. The municipalities of Dedoplistskaro and Sagarejo have a lower land productivity as the climate is characterised as semi-arid as opposed to temperate in Gurjaani, Telavi and Akhmeta.

2.11 Conclusion chapter 2 and next steps

The above chapter and NDVI analysis demonstrate evidence of land degradation in specific areas of Dedoplistskaro winter pastures. Further analysis of these areas would be merited, to understand what is driving degradation. In the next chapters, we consider three sustainable land management approaches that can be used to halt degradation and favour rehabilitation of pasture productivity.

Cattle farm -
year round pastures

03

Sustainable pasture management interventions in Kakheti

Overgrazing and unsustainable grazing management adversely impacts the quantity and nutritional value of pasture and hayland. The Society for Range Management definition of overgrazing is continued grazing which exceeds the recovery capacity of the community and creates loss of plant cover and accelerated erosion.[6] Rangeland degradation can be addressed through both continuous grazing that carefully balances forage resources with forage demand or rotational grazing schemes that incorporates forage recovery periods. We evaluate three distinct land management interventions that may be used to reverse the deterioration of rangeland.

The three interventions are described below and in the following chapters we assess their impact on pastoral household economies relative to Business as Usual, which is characterised by continuous grazing above the carrying capacity of land.

3.1 SLM Intervention 1: Adjusting herd sizes under continuous grazing

Most commonly, land degradation is addressed by balancing forage demand with forage production (Etzold and Neudert 2020, George et al. 2020, Pachzelt et al. 2013). Proper use factors (PUF) define the percentage offtake which can be sustained by the pasture without reducing its productivity in future years.[7] When proper use factors are exceeded, herbage utilisation does not permit desirable forage species to maintain themselves (Klippe and Bement 1961). This is termed heavy grazing, or grazing above the carrying capacity of land.

In North America for example, a meta-analysis of 30 long-term grazing studies, showed that forage production is 23% higher under moderate grazing (grazing at the Proper Use Factor) than heavy grazing (Holechek et al. 1999). Heavy grazing further resulted overall in a 20% decline in forage production over time and moderate grazing led to no change and light grazing (below PUF) to an 8% increase.

This evidence suggests that, with the imposition of a moderate grazing regime as we analyse in the following chapter, it is possible that pasture productivity could increase by 20%. But this assumes both that pastures really are heavily grazed, and that they are able to fully recover from this state to fully reflect the new moderate grazing regime. Unfortunately, we do not have data from Kakheti to show whether this would be the case.

The valuation study therefore focuses on the direct economic impact of balancing forage demand with forage supply that is felt by pastoral households.[8] Notably, de-stocking involves forgone costs from the sale of livestock, milk and cheese in future years. We also consider how this impact varies according to the size of the pastoral enterprise and prevailing land tenure arrangements.

Additionally, since overgrazing usually takes its toll when animals exhaust forage during the non-growing season, it is the amount and quality of standing forage available at the onset of the non-growing season that largely determines the stocking rate and grazing plans. We therefore focus on the case for de-stocking at the beginning of the slow/no growing season.

3.2 Rotational grazing

Rotational grazing systems have been widely recommended by government agencies concerned with rangeland degradation. Studies have

6 https://rangelands-gateway.org/glossary
7 In Soviet rangeland science these are known as coefficients of use, expressed as permissible offtake as a percentage of total biomass.
8 This is also a realistic reflection of how pasture users may perceive the impact of de-stocking, as many have insecure tenure (short tem leases, or sub-lease contracts) and can therefore not reap the benefits of improved pasture productivity.

shown that long rotational grazing systems can give equal or superior vegetation to continuous grazing, conditional on moderate grazing (Heitschmidt et al. 1990, Holechek et al. 1987, Taylor et al. 1993, Westerberg and Myint 2015). In the meta-analysis by Holechek et al. (1999), forage production was on average 7% higher under rotation compared to continuous grazing. However, in the semi-arid and desert range types such systems perform no better than well-managed continuous grazing (Briske et al. 2008, Holechek et al. 1999). In terms of rotational grazing, we consider two different systems, notably, multi-paddock adaptive systems and annual rotations.

3.2.1 SLM intervention 2: Multi-paddock adaptive grazing and holistic planned grazing

Adherents of multi-paddock adaptive grazing systems consider that land benefit from larger herds, high density and rapid shifts of animals to fresh and nutritious grass (Savory 1983). From the standpoint of Holistic Planned Grazing for example, overgrazing occurs when plants are exposed to the animals for too many days, rather than at excessive stocking densities (Savory and Butterfield 1999). Overgrazing can therefore be avoided by favouring short-duration and high frequency rotational grazing. By planning the moves of animals according to the recovery time of grasses, forage growth is optimized. The benefit of this grazing system is valued through its contribution to improved forage productivity in the same year as the intervention is undertaken.

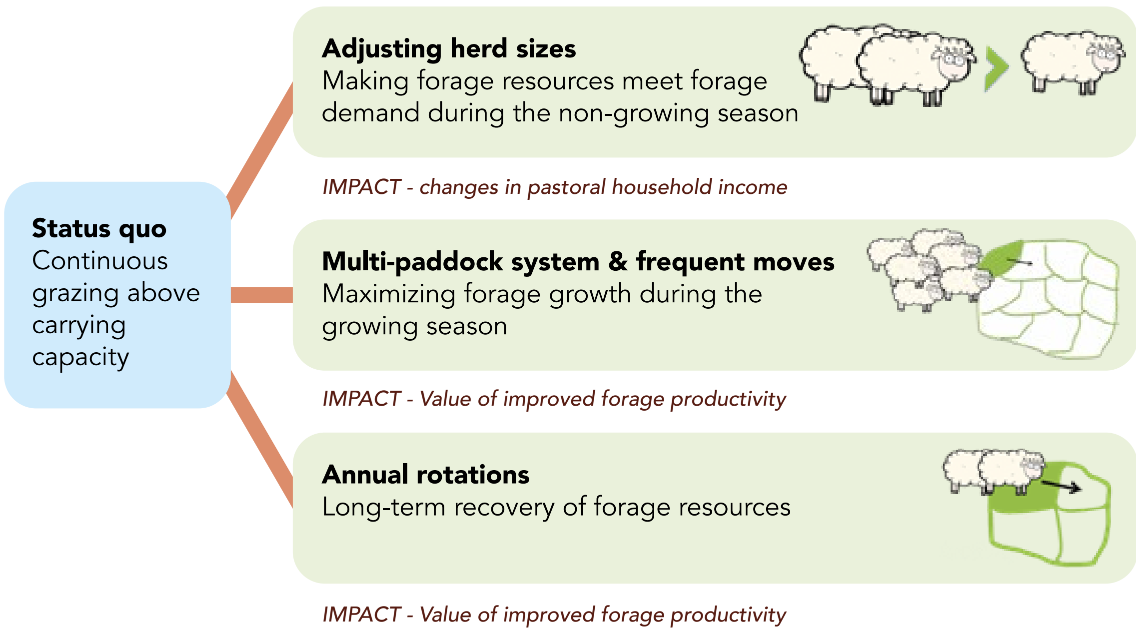
3.2.2 SLM intervention 3: Annual rotational grazing and exclosures

Multi-paddock grazing schemes used in Holistic Planned Grazing may be distinguished from simple deferred **annual rotational systems** that use much longer periods between grazing without explicit consideration of the recovery time of plants after grazing (Heitschmidt and Taylor 1991).

Here we consider the case for yearly rotations, whereby one quarter of the land is protected for a year, the next year another quarter is protected, and so forth. The forage that regenerates therefore becomes available the following year. As such, there is an opportunity cost in terms of foregone opportunities of grazing in the first year. The improvement in forage resources the following year is valued in terms of the avoided spending on forage resources.

FIGURE 15

Sustainable land management strategies evaluated



[9] *For example, when animals re-graze the plants as they try to regrow; when animals move away but return too soon and graze while the plant is still using stored energy to reform leaves; or immediately following dormancy when plants are growing new leaves from stored energy.*

3.3 Conclusion chapter 3 and next steps

To date, there has been neither a rejection of rotational grazing, nor a validation of continuous season-long grazing as superior to rotational grazing (Budd and Thorpe 2009). However, whilst there is not a "golden rule" to sustainable pasture management there is evidence that each intervention evaluated here represents an improvement over current practices from the perspective of avoiding further land degradation and regenerating pastoral land resources.

These SLM interventions therefore merit a proper evaluation relative to "business as usual" (BAU), which is characterized by heavy and continuous grazing on public and privately owned or leased pasturelands above the carrying capacity.

Ungrazed Bothriochloeta winter pastures

04 SLM Intervention - Adjusting herd sizes under continuous grazing

In Georgia, the relevant parameter determining the overall stocking numbers is the available forage on winter pastures, since these are scarcer and more prone to drought relative to summer pastures (Raaflaub and Dobry 2015). In this chapter, we assess the case for reducing stocking densities during the non-growing season by assessing forage supply and forage demand on winter pastures. We also consider how households would be affected by efforts to adjust animal numbers according to the carrying capacity of land.

Changing animal numbers will impact the revenue flow of pastoralists due to forgone future earnings, while some costs such as pasture lease, will remain fixed. To understand how households are impacted by such changes, we also establish budgets of pastoral enterprises, using the following steps:

1. Present the socio-economic data inputs and ELD household survey that have been undertaken.
2. Undertake a cluster analysis, to represent the underlying population of pasture users.
3. Establish a pastoral household budget and income analysis major pasture user groups, migrating and residents.
4. Assess total usable forage (supply) in Kakheti, during the non-growing season.
5. Assess total demand for forage on the basis of stocking densities in Kakheti as a whole and individual pasture user groups.
6. Value the impact of adjusting animal numbers on the household economies of major pasture user groups, such that forage demand meets forage supply during the non-growing season.
7. Undertake a sensitivity analysis, presuming that land lease costs were lowered, e.g. through Common Property Resource Management Schemes.

4.1 Socio-economic data inputs, the pastoral household budget

To prepare for the study, a socio-economic household survey and baseline economic analysis were undertaken. Appendix 3 explains how the sampling frame, sample size and the target respondents were defined. The survey comprised of 80 questions using multiple choice or short form open numeric responses. The questionnaire was pre-tested in the municipality of Dedoplistskaro March 2018, with the assistance of GIZ local field office.

The household survey was designed for the purpose of doing a household income analysis for representative pasture user groups and understand land tenure. Some variables, such as cost of supplementary feed, household food budget and fuel were taken from the literature. The household survey was implemented in April and May 2018. The survey responses were entered directly into SurveyXact software using handheld electronic tablets. There were 355 complete responses in total, representing with 90 % confidence the underlying population of pastoralists and 19% of known female sheep holdings[10] for Kakheti, 6% of cattle ownership and 14% of goat ownership.

4.2 Land tenure and livestock numbers

Thirty-nine percent of the sample were found to migrate their stock seasonally, whereas the remaining 61% remained at the pastures near

[10] We chose to ask about female sheep only because "sheep" in generality includes females plus adult lambs of both sexes; and because there is census data on ewes. Whilst it would be ideal to include adult rams as well, it was important to strike the balance between questions we deemed absolutely necessary while also trying to minimise the length of time each survey took to complete.

TABLE 3

Livestock numbers and land tenure amongst pastoralists in Kakheti

	Whole population	Migrating	Residents
Livestock numbers, mean and std dev (in bracket)	302 (566)	627 (752)	96 (247)
Share of migrating and resident pastoralists	100%	39%	61%
Households leasing pastureland, of which:	24%	43%	12%
Direct leases	74%	74%	72%
Sub-leases	27%	26%	28%
Households owning pasture land	5%	7%	4%
Households leasing and/or owning pastureland	**28%**	**50%**	**15%**
Households use only public or communal pastureland or the land of other pastoralists	72%	50%	85%

their home all year round. Migrating household have an average of 627 sheep units and lease 273 hectares of pastureland. Resident pasture users have an average of 97 sheep units and rent on average 29 ha of pastures.

As shown in Table 3, only 28% of the population have some form of tenure security in terms of either leasing or owning pastureland. Migrating pasture users have a higher share of land ownership and leasehold. However, of the households leasing pastures, whether migrating or resident, an astounding 27% have sub-leases. Seventy-two percent of sample households neither own nor lease land.

4.3 Segmentation of households by livestock ownership

There are several distinct categories of pasture-user in Kakheti, varying from households with a few heads of livestock to large farm businesses with thousands of sheep. For each pasture-user profile there will be different levels of profitability. Cluster analysis was used to group households according to a combination of livestock ownership and seasonal migration status.[11] This process produced eight clusters or 'profiles' 5 of which are migrators and 3 of which are residents (see Appendix 3 for full details of the analysis). The analysis is similar to the approach taken by Serneels et al. (2009) of Maasai pastoralist livelihoods, or those of Thompson and Homewood (2002), or Williams (1994).

Seasonal migrators use the pastures in lowland Kakheti during the winter months, then move their livestock to the summer pastures in the mountains. Table 4a shows the profiles defined for migratory households, and the size of these segments within the sample data. There are three clear clusters with sheep, goats and cattle, a fourth profile having sheep and goats only and a fifth profile owning only cattle.

Resident households do not move their livestock during the summer months and the majority live in the lowland of Kakheti all year round, with the exception of a few Tushetian pastoralists that use the summer pastures all year. There is one large robust cluster for this pasture-user profile, characterised by households owning sheep, goats and cattle (Table 4b). It is also common for residents to have cattle only (31% of resident pasture users). Overall, it can be seen that residents have fewer sheep units relative to migrators and amongst migrators and residents, there is a small percentage that has a very large number of livestock.

[11] Welch's unequal variance two sample t-test with a 95% confidence interval was applied to determine whether migration or resident status, was significantly associated with the size of livestock holding, which it was.

TABLE 4A

Pasture-user profiles for migratory households

Migrators	% households	Stocking density on leased land	Sheep	Goats	Cattle	Sheep units*	Pasture Lease (ha)
Migrator 1	14%	7.3	0	0	37	**222**	30
Migrator 2 (Small)	35%	2.3	265	15	19	**390**	168
Migrator 3	32%	2.5	574	27	0	**601**	240
Migrator 4 (Medium)	16%	2.1	825	25	38	**1071**	508
Migrator 5 (Large)	3%	2.5	1960	60	90	**2542**	1024

For the purposes of illustrating the impact of changing stocking densities on pastoral household economies, the subsequent analysis was conducted with respect to three migrating pasture users (small, medium and large) and the largest cluster of resident pasture users, representing 68% of all resident pasture users in Kakheti. These are grey-highlighted in Tables 4a and 4b.

4.4 Baseline assessment - pastoralist household income

4.4.1 Revenue from the sale of livestock, milk, cheese and wool

The main source of revenue for pastoralist households is the sale of livestock and their offspring. The average market prices for livestock as calculated from the household survey are given in Table 5. These results are within the range of existing literature.

The income per household for milk, cheese and wool were analysed. Seventeen percent of all survey respondents sell neither cheese nor milk, whereas 61% of the households surveyed said that they produced cheese from cows or sheep milk. Twenty-seven percent of surveyed households said that they sold milk. Households that migrate seasonally were found to be more likely to produce cheese, and less likely to produce milk. Migrating pasture users were also more likely to sell wool. On average, each sheep in Kakheti produces 1.5kg of wool per annum (Gonashvili et al. 2013). The prices for

TABLE 4B

Pasture-user profiles for resident households

Residents	% households	Stocking density on leased land	Sheep	Goats	Cattle	Sheep units*	Pasture Lease (ha)
Resident 1	31%	7.3	0	0	16	**96**	13
Resident 2	68%	2.5	122	17	16	**230**	94
Resident 3	2%	2.5	3000	50	150	**3950**	1580

TABLE 5

Livestock prices in Georgian Lari (GEL)

	Lamb	Ewe	Goat	Calf	Cow	Pig
Price per unit (GEL)	146	133	129	490	**1177**	284

TABLE 6

Prices of cheese and wool in Georgian Lari (GEL)

	Cheese	Wool
Price per kilogram (GEL)	8.43	0.36

cheese and wool were normally distributed and are given in Table 6.

4.4.2 Variable and fixed costs of pastoralism, assumptions

The variable costs in the pastoralist household budget include veterinary costs per sheep unit, salt per sheep unit, livestock feed, number of hours labour per year and cheese making costs and livestock feed. Information on these cost items is derived from the household survey. The wage for pastoralist workers was taken from the literature to be GEL 500 per month (ELKANA 2014).

The fixed costs of pastoralism include household food budget, taxes, fuel requirement, the cost of vehicles owned by the household, cost of machinery and lease of pasture land. Cost of pasture lease is considered fixed, to the extent that farmers may not be able to change their contract from one days.

4.4.3 Cost of supplementary livestock feed

Supplementary fodder cost was calculated from the survey responses, regarding volumetric purchases of straw, hay and concentrated feed. The cost for livestock fodder was taken from the literature ((ELKANA 2014, Gonashvili et al. 2013, UNDP 2014), with hay costing 0.21 GEL/kg, straw 0.12 GEL/kg and concentrate 0.62 kg/ha.

Supplementary feed represents the largest single cost for pastoralists in this region. As seen in Table 7, livestock owners spend on average between GEL 21 to 42 per sheep unit on supplementary fodder. This is very significant. It is also noteworthy that the mean cost of supplementary fodder per sheep unit for resident pasture users is almost double that of migratory profiles. The results suggest that spending on forage is higher than previously thought. In other studies, the cost of additional forage has been found to be in the order of GEL 9 per sheep unit (ELKANA 2014, Gonashvili et al. 2013). These studies focused on feed requirements for sheep. The inclusion of cattle in this study, may partly explain the higher additional food requirement.

4.4.4 The pastoral household budget

Revenues and costs have been combined for each pasture user profile to calculate an annual net income per household and sheep unit, following Equation 1 through to 5 and reported in Table 6.

Equation 1

Revenue = Price x Products sold
Products sold, include livestock, wool, cheese, milk

Equation 2

Variable cost = veterinary + salt + cheese-making + labour/herding costs

Equation 3

Gross Income = Revenue – Variable costs
Variable cost includes, veterinary, salt, cheesemaking costs and labour for herding, lambing and milking

TABLE 7

Cost of additional food per household profile

Profile	Volume of additional dry matter given per sheep (kg)	Volume of additional dry matter given per cow (kg)	Sheep units	Total cost to household (GEL)	Total cost per sheep unit (GEL)	Additional cost to household (GEL)
Small migrator	24	757	394	9,619	25	6,033
Medium migrator	24	757	1,071	22,498	21	12,641
Large migrator	24	757	2,542	53,362	21	29,955
Resident	83	757	230	9,769	42	7,652

Equation 4

Net income/profit = Gross Income – Fixed costs

Fixed household costs include taxes, pasture land lease, machinery, food, fuel, vehicle

Equation 5

Net income per SU = Net Income/SU

SU stands for sheep unit

4.5 Cost of supplementary livestock feed

As shown in Table 8, net income varies widely amongst pasture users, which is a result of the different revenue streams and land tenure schemes that they have available to them. Land lease costs and supplementary feed weigh heavily in the budgets. Cheese making is a particularly profitable activity, providing an important source of income for almost all types of pasture user.

Migratory households are generally more profitable than resident households. This finding

FIGURE 16

Profitability of livestock production for four pastoral household profiles

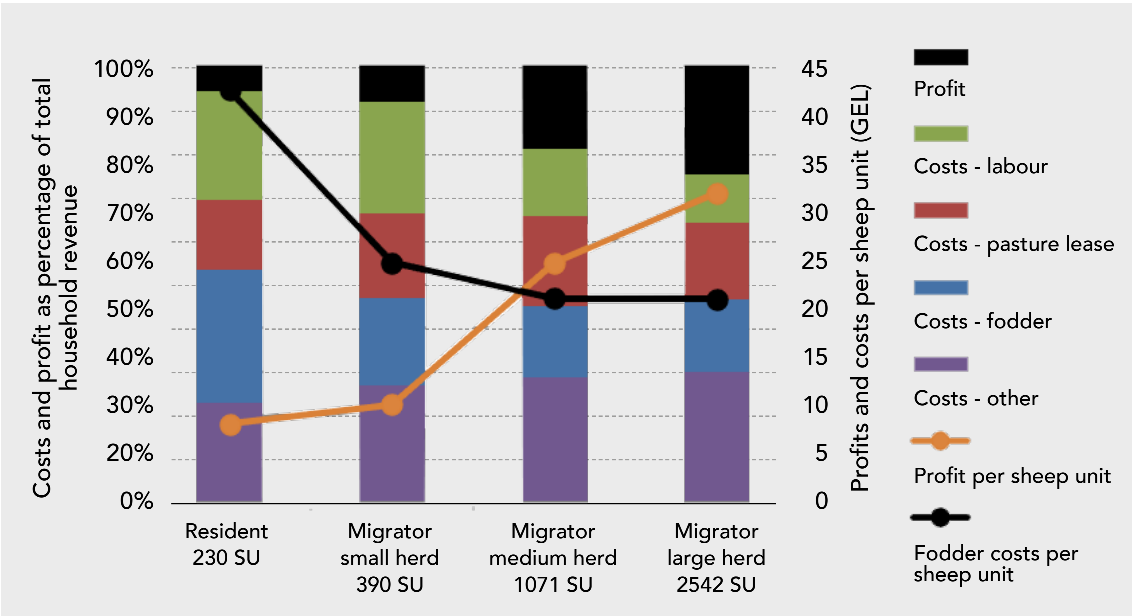


TABLE 8

Annual household budget for migratory and resident pastoralists, in Kakheti

SLM interventions	Migrator Small herd	Migrator Medium Herd	Migrator Large herd	Residents
BASELINE				
Sheep units	***390***	***1'071***	***2'542***	***230***
REVENUES				
Livestock sales	38'023	104'436	247'988	22'454
Wool	143	446	-	-
Cheese	5'582	8'754	-	5'601
Milk	1'391	-	-	2'883
Total revenue	**45'139**	**113'635**	**247'988**	**30'938**
COSTS				
Variable costs				
Vet	491	1'349	3'203	290
Supplementary feed	9'619	22'498	53'362	9'769
Salt	319	853	2'024	195
Cheese making cost	319	239	-	153
Labour				
Shepherds	8'624	13'296	28'826	5'380
Lambing	1'996	3'078	6'673	1'150
Milking	1'690	4'646		1'513
TOTAL VARIABLE COSTS	**22'891**	**45'958**	**94'087**	**18'448**
GROSS INCOME	**22'248**	**67'677**	**153'900**	**12'491**
Fixed costs				
Lease of pastures	9'316	28'262	56'910	5'147
Machinery	1'145	2'650	4'375	531
Family food	5'370	7'857	9'060	4'320
Firewood or fuel	481	481	481	623
Vehicle	1'989	1'989	1'989	-
FIXED HOUSEHOLD COSTS	**18'301**	**41'239**	**72'815**	**10'621**
Lease as a % total cost	***23%***	***32%***	***34%***	***18%***
Feed as % total cost	***23%***	***26%***	***32%***	***34%***
NET INCOME	**3'946**	**26'438**	**81'085**	**1'870**
Margin	*9%*	*23%*	*33%*	*6%*
Net income per sheep unit	*10*	*25*	*32*	*8*

resonates studies in other countries, mainly because the cost of fodder per head is so high for small sedentary flocks (for example see Kerven et al. (2004)) Large migratory households that are particularly well-off. Despite holding large herds, they have the same amount of fixed costs as other pastoralist households. This allows them to create economies of scale, generating higher net-income per animal. However currently, pastoralists with large herds represent only 3% of migrating pastoralists in Kakheti. Figure 16 illustrates how total profit and profit per sheep unit increase with herd size, whilst fodder costs per head decrease. These costs are particularly onerous for resident households.

4.6 SLM strategy 1: Balancing forage demand with forage supply during the non-growing season

The 'Supply-Demand Balance' approach is a methodology for estimating maximum sustainable stocking rates on pastureland recommended by Holechek (1988). This approach serves to establish the carrying capacity of the pastureland and balance it with biomass demand. We do this by focusing on stocking densities during the non-growing season, since overgrazing usually takes its toll during the winter (Savory Institute 2018).

The key steps involved in implementing this methodology are:

- Assessing total forage supply. This is done on the basis of the total amount of forage available in each of the municipalities at the start of the non-growing season using biomass for the winter 2016/2017 as a reference (Appendix 2 outlines how the data were obtained).
- Assessing forage demand, based on the total number of livestock found in each municipality.
- Comparing forage supply to forage demand from livestock in the region.
- Drawing on the household budgets in the previous section, we finally:
- Value the impact of changing animal numbers on pastoral household income.

[12] *http://www.webpages.uidaho.edu/range357/notes/stocking-rate.pdf*

Estimating total usable forage supply

The total above ground biomass for Kakheti was calculated from satellite imagery for the end of October 2016, as this coincides with the start of the slow-growing season. Following Holechek (1988), we estimate actual useable forage by adjusting forage availability by the proper use factor (PUF), defined as the offtake which can be sustained by the pasture without reducing its productivity in future years. When proper use factors are exceeded, herbage utilisation does not permit desirable forage species to maintain themselves (Klipple and Bement 1961) and land is grazed beyond it carrying capacity. Sources at the University of Idaho suggest 30-40% PUF for sagebrush grasslands, which is the common name of plants in the genus *Artemisia*[12], similar to winter pastures in Kakheti. Moreover, according to Holechek et al. (1999) moderate grazing should not remove more than 35% to 45% of forage in semi-arid grasslands and deserts rangelands. On the basis of these figures, we assume a proper use factor of 40% for *Artemisia* and *Bothriochloa* dominated rangelands in Kakheti.

Equation 6:

Total usable forage supply for Kakheti
= Total biomass/total pastureland x PUF of 40%
= (154'453'889 kg / 381'338 ha) x 0.4 = 162 kg/ha

Biomass estimates for winter pastures based on Equation 6 are provided in Table 8. Not all forage is available for grazing however. Holechek (1988) further advises to reduce the usable forage allowance by adjusting for slope with a gradient greater than greater than 30% and for pastoral resources that are further than 1 mile away from water. However, the locations of water sources in Kakheti are unclear and only 5% of pastureland has gradients greater than 30% (Costa, personal communication). We have therefore not adjusted usable forage on the basis of these elements.

Estimating forage demand of grazing livestock

The daily forage dry matter demand of grazing livestock is estimated based on the population of livestock within Kakheti and the dry matter forage requirements per animal. Following Rinehart and Baier (2011), ruminants eat 2.5% of their body weight per day on rangeland, rising to up to 4% if they are lactating. Since lambing takes place during the winter, it is reasonable to assume daily forage utilization equivalent to 3% of their body weight. For an average sized ewe of 50 kg (Gonashvili et al., 2013), this results in a daily consumption of 1.5 kg of dry matter. Expert consultations suggest that the weight of adult cattle is taken to be 300 kg which leads to a daily intake of 9 kg of dry matter.

Equation 7:

Daily forage demand

= Number of animals x Average animal weight x 3%

= 50 kg x 0.03 = 1.5 kg/day

The daily forage demand is multiplied by the estimated duration of the non-growing season, 90 days – to obtain total dry matter demand during the non-growing season.

Equation 8:

Dry matter demand

= daily forage demand x duration of the non-growing season

= 1.5 kg DM/day x 2.6 SU/ha x 90 days = 345 kg DM

Balancing forage supply with forage demand

The supply of total accessible forage supply is compared to the total dry matter demand per year. Table 9 shows the data used to calculate the supply-demand-balance and destocking scenario. The total area of grassland is taken to be that detected through satellite imagery, but is compared here to those provided by government sources (RECC 2018, personal communication).

Table 10 shows the balance between supply of forage and demand from current levels of livestock holding in Kakheti. Application of the supply-demand-balance approach indicates that 1.2 sheep units can be supported per hectare of winter pasture in Kakheti during the non-growing season. The current average of sheep units in Kakheti is 2.6 per hectare, so overall a destocking of 1.4 sheep units per hectare would be required in order to match forage demand to the carrying capacity of pastureland. There are many regional differences, with the highest difference between supply and demand is seen in Telavi and Sagarejo municipalities. However, it should be noted that the high population of migratory households makes it difficult to draw strong conclusions based on municipalities alone and recommendations for the Kakheti as a whole would be more robust.

TABLE 9

Total biomass and areas of pasture in Kakheti

Municipality	Total above ground biomass on winter pastures, start of slow-growing season (kg)*	Total area of grasslands as detected by satellite imagery (hectares)*	Total number of ewes in 2016**	Total number of cattle in 2016**	Total number of goats in 2016**
Dedoplistskaro	78,782,672	184,671	79,453	10,000	1,545
Akhmeta	13,816,354	55,980	25,753	10,915	1,948
Telavi	3,345,034	7,236	18,617	7,190	1,907
Gurjaani	3,801,992	7,569	8,071	5,279	1,282
Sagarejo	23,900,387	54,774	185,945	31,079	12,635
Other	30,807,451	72,108	51,461	32,737	3,982
Total Kakheti	**154,453,889**	**382,338**	**369,300**	**97,200**	**23,300**

TABLE 10

Balance of forage supply to forage demand in Kakheti*

Municipality	Supply of forage per hectare on winter pastures end October (kg)	Demand for forage per hectare for 90 days over the non-growing months (kg)	Sheep units per hectare that can be supported during non-growing season	Current sheep units per hectare	Difference in sheep units
Total Kakheti	162	345	1.2	2.6	-1.4

The stocking densities per pasture-user profile as derived from the results of the household survey are given in Table 11 below. These densities were used to calculate the number of sheep units that each household would be able to keep on their land and are compared to the number of sheep units that can be supported during the growing season on winter pastures.

Estimating household cost and benefits of de-stocking

The baseline household budget in the previous chapter can be used to value the cost of a de-stocking scenario to pastoralist households. In the first year, and in every following year, the household foregoes revenue from livestock sales, wool, milk and cheese production. This loss is partly offset by the avoided cost of supplementary food for the remaining livestock holding owned by the household. It is also assumed that the cost of leasing pastureland does not change in order to simulate the impact of de-stocking - i.e. the same amount of land is used after destocking but livestock numbers change. On this basis, the forgone income and Net Present Value impact of destocking is calculated following Equation 9 through to 11.

Equation 9:

Gross income per SU$_{\text{baseline}}$ = Gross Income/SU

SU stands for sheep unit

The net income which remains after de-stocking is simply the gross income under the new number of sheep units, less the fixed costs of the pasture enterprise, plus the avoided forage costs associated with the smaller number of sheep units.

Equation 10:

Net-income$_{\text{de-stocking}}$
= (Gross income/SU x #SU$_{\text{de-stocking}}$) – fixed costs + avoided forage costs

Fixed household costs include taxes, arable and pasture land lease, machinery, fuel, vehicle, food for family.

TABLE 11

Current sheep units per hectare for each pasture-user profile *(Source: ELD Household Survey)*

Pasture-user profile	Number of leased hectares of pastureland per sheep unit
Small herd migrator	2.3
Medium herd migrator	2.1
Large herd migrator	2.5
Resident	2.5

The annual net-benefit from destocking is given by the difference between the net-income from de-stocking, less the net-income in the baseline scenario. The net-benefit can be positive or negative. The flow of net-benefit over 5 years are discounted to yield the Net Present Value of de-stocking and includes the revenues from the one-off sale of livestock in the first year (t=0). We use the real interest rate of 4% for discounting future cashflow (t=1 to t=4) based on similar research in this region of Georgia for the time period of 2015 (Westerberg et al. 2016).

Equation 11:

Net Present Value

$$= \sum_{t=0}^{4} \frac{\text{Net income}_{\text{de-stocking}} - \text{Net income}_{\text{baseline}}}{(1+r)^{t}} + \text{one off sale of livestock}_{t=0}$$

4.7 Results, de-stocking for all pasture-users

The results of this analysis are given in Table 12, on the basis of a 5-year time horizon. As can be seen, amongst the migrating pastoralists, medium and large migrators would still be able to earn an annual positive net-income after de-stocking and cover their fixed costs. However, annual earnings are reduced significantly, e.g. from EUR 81,085 to EUR 15,000 for the large migrators. Over a 5-year period the Net Present Value is therefore negative, even when accounting for the one-off gain from the sale of livestock. In the case of resident pastoralists, the sale of livestock would cover the loss of income from their reduced livestock holding. This outcome is conditional on unchanged prices in livestock, which cannot be guaranteed.

On an annual basis, when ignoring the one-off gain from the sale of livestock, households with small herds would be unable to cover their annual living costs if they were required to reduce their

TABLE 12

Annual ongoing cost or benefit of destocking to each type of pasture-user

With lease-costs	Migrators - Small herd	Migrators- Medium Herd	Migrators - Large herd	Residents
Baseline				
Sheep units	13,816,354	55,980	10,915	1,948
Current stocking/ha	3,345,034	7,236	7,190	1,907
Net income	3,801,992	7,569	5,279	1,282
Net income per sheep unit	23,900,387	54,774	31,079	12,635
Destocking intervention				
Sheep units reduced	-190	-465	-1'322	-110
New number of sheep units	200	606	1'220	120
New stocking rate/ha	1.2	1.2	1.2	1.3
Net income	***-3'799***	***4'224***	***15'435***	**-146**
Net income per sheep unit	***-19***	***7***	***13***	**-1**
Net Present Value (5 years)*	**-4'749**	**-13'539**	**-120'417**	**9'579**

BOX

NPV calculation, small herd migrator

After destocking, the migrator with a small herd, would receive the one-off benefit of the livestock sale for GEL 30,920, assuming that market price remains unchanged despite an increased supply to the market. The annual flow of net-benefits, in each year is totalled then discounted at 4% to yield the Net Present Value of negative GEL 4750. Despite a large positive gain from the sale of livestock, the pasture user is worse off after de-stocking.

	Year 1 2018	Year 2 2019	Year 3 2020	Year 4 2021	Year 5 2022
Net income before destocking	3'946	3'946	3'946	3'946	3'946
Net income after destocking	-3'799	-3'799	-3'799	-3'799	-3'799
One-off livestock sale	30'920				
NPV @ 4%	-4'749				

livestock holding to meet the carrying capacity of pastureland (negative net-income from destocking). Although pasture resources would cease to degrade according to Holechek et al. (1999), this impact would not be enough to bring pastoralists into profitability. Appendix 4 shows the full details of the household destocking budgets.

4.8 Feasibility of de-stocking under other land tenure schemes

For small migrating pastoralists that rely on land rental of winter pastures, it is prohibitively expensive to de-stock (Figure 17). It can therefore not be expected that this strategy would be

TABLE 13

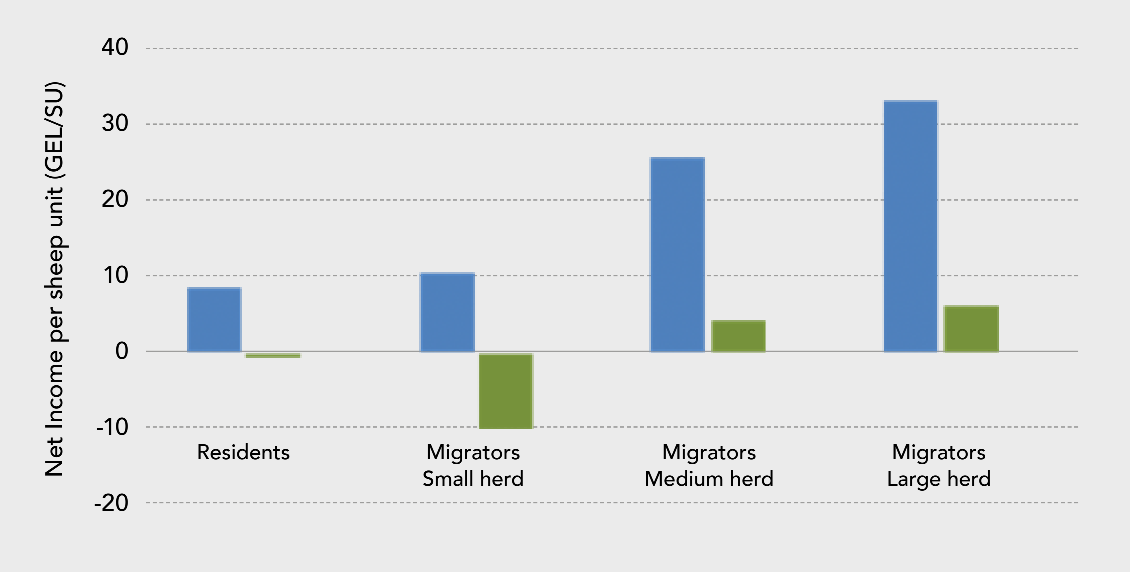
Net-income after de-stocking, in the absence of pasture lease costs

**Accounting for the revenue from a one-off livestock sale in the first year*

No land lease-costs	**Migrators - Small herd**	**Migrators- Medium Herd**	**Migrators - Large herd**	**Residents**
Baseline				
Sheep units	390	1'071	2'542	230
Current stocking/ha	2.3	2.1	2.5	2.5
Net income	22'248	67'677	153'900	12'491
Net income per sheep unit	34	51	54	31
Destocking intervention				
Sheep units reduced	-190	-465	-1'322	-110
New number of sheep units	200	606	1'220	120
New stocking rate/ha	1.2	1.2	1.2	1.3
Net income	**13'263**	**54'700**	**137'995**	**7'017**
Net income per sheep unit	**28**	**54**	**59**	**42**

FIGURE 17

Net-income per sheep unit before and after de-stocking, with current level of pasture lease costs



adopted to the extent required to bring animal numbers down to carrying capacity of winter pastures during the non-growing season.

However, in the absence of pasture leasing costs, our results suggest that all of our main pasture user groups, independent of herd size, would be able to retain a positive net-income after destocking (Table 13, Figure 18). Therefore, a policy, which aims to recover forage resources through de-stocking, is likely to be more successful under land tenure schemes with low pasture access fees, such as common property regimes where resources can be pooled, than under individualized pasture.

4.9 Willingness to destock

The results from the ELD pastoral household survey (2018) demonstrate that only 36% of households are supportive of a destocking pol-

FIGURE 18

Net-income per sheep unit before and after de-stocking, in the absence of pasture lease costs

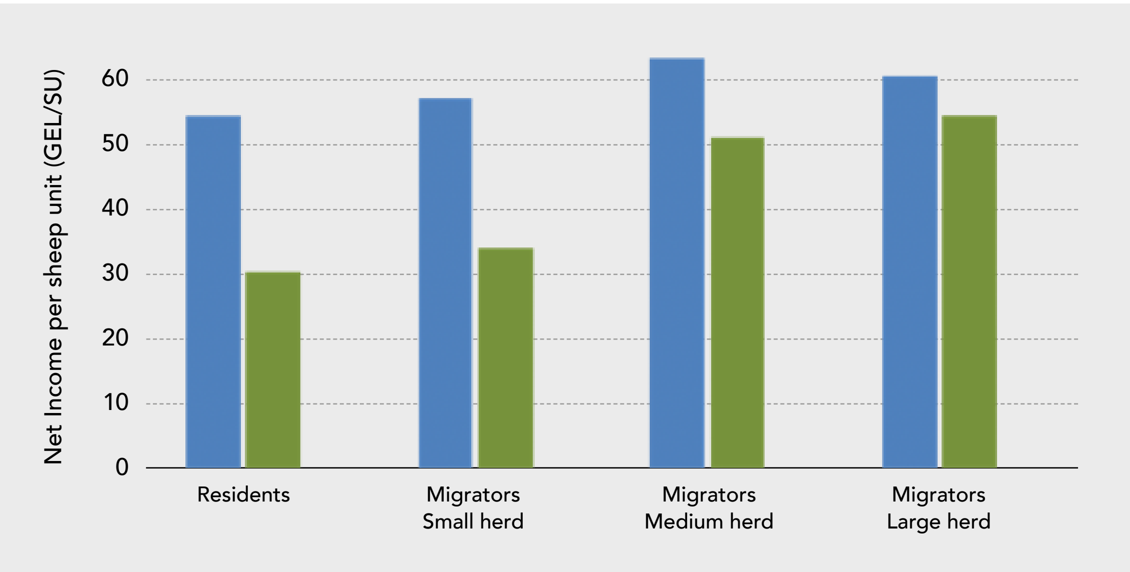
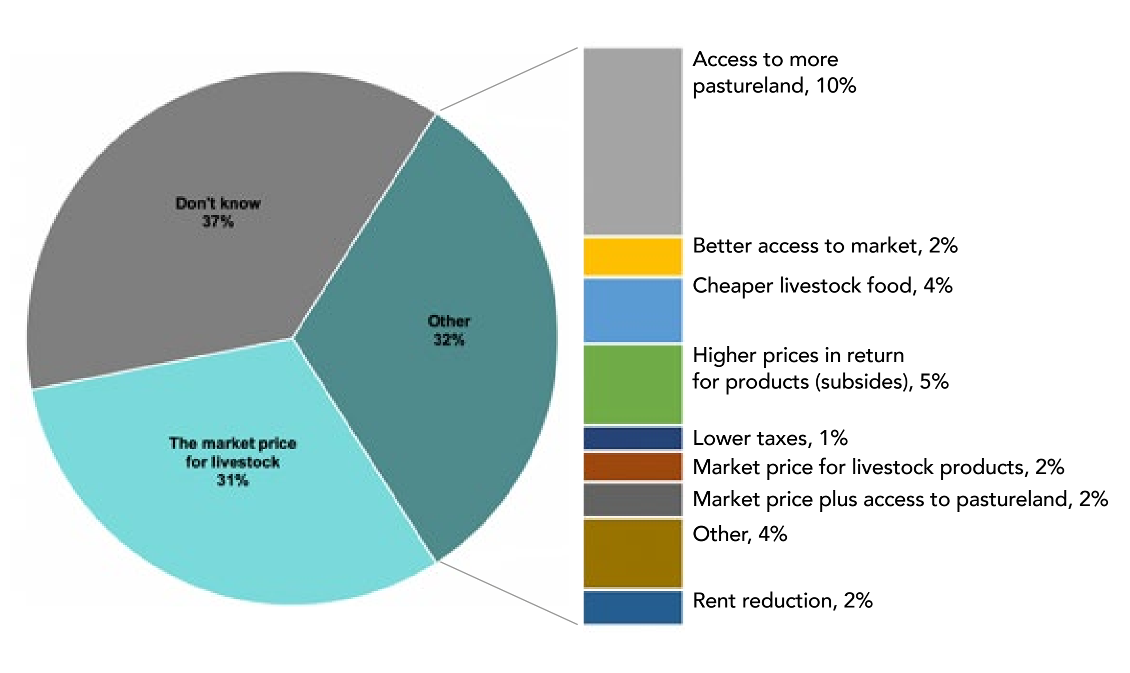


FIGURE 19

Net-income per sheep unit before and after de-stocking, in the absence of pasture lease costs



icy.[13] In terms of what the pastoral household would require in compensation for de-stocking, Figure 19 shows that 31% of the survey respondents would request the market price for livestock as a minimum, but as is seen in the valuation of this scenario (section 4.10) this is not sufficient to cover the on-going loss of household income. Ten percent of respondents would hope for access to more pastureland, as this would be a way to maintain livestock numbers, while reducing the stocking density per hectare. However, a parallel report to this (Robinson 2018) indicates that this would be difficult to implement since there is little additional capacity to increase the leasing of pastures.

4.10 Willingness to destock

De-stocking is expensive for pastoralists, as they have significant fixed costs that need to be covered, independently of herd size. The cost of having individualized leaseholds is adding to this, whilst cooperative schemes allowing for the pooling of resources, would make it cheaper. Pastoralists on individual leaseholds are not likely to adopt a de-stocking strategy, unless they understand the adverse consequences of grazing beyond the carrying capacity of land, have secure land tenure and receive compensation for de-stocking.

The next two chapters show there are other ways to regenerate land resources and generating forage for the non-growing season, hereby reducing the need for de-stocking.

[13] However, 68% of households stated they would be willing to carry out SLM practices

05 SLM strategy 2: Multi-paddock adaptive grazing

De-stocking in Kakheti to meet forage supply in the non-growing season, will help halt future land degradation. In the previous chapter we evaluated the impact on the pastoral household economy.

In this chapter, we show how the regeneration and harvesting of biomass may be optimized during the growing season using multi-paddock adaptive grazing, which lowers the need for providing supplementary forage in the non-growing season. In doing so, we draw on principles of Holistic Planned Grazing, developed by the Savory Institute (2018).

5.1 Background on holistic planned grazing & multi-paddock adaptive grazing

Holistic planned grazing (HPG) management offers a set of tools aiming to improve land productivity, including financial, grazing and land planning. Grazing planning aims to optimise plant growth, keeping the livestock fed and helping shepherds mitigate risk by improving their ability to foresee adaptive actions in the case of an unexpected event such as a drought. Typically, one plan is made for the growing season and another made for the non-growing season.

The aim of the growing season is to maximise forage production and the grazing plan is "open", reflecting that pastoralists adapt grazing practices and paddock systems to changing conditions that impact forage growth.

The aim of the of the slow or non-growing season is to ration out a known amount of forage grown in the previous growing season, for example through de-stocking as evaluated in the previous chapter, or harvesting surplus hay during spring to be provided as food supplements during the non-growing season.

5.2 Using paddocks to create recovery periods

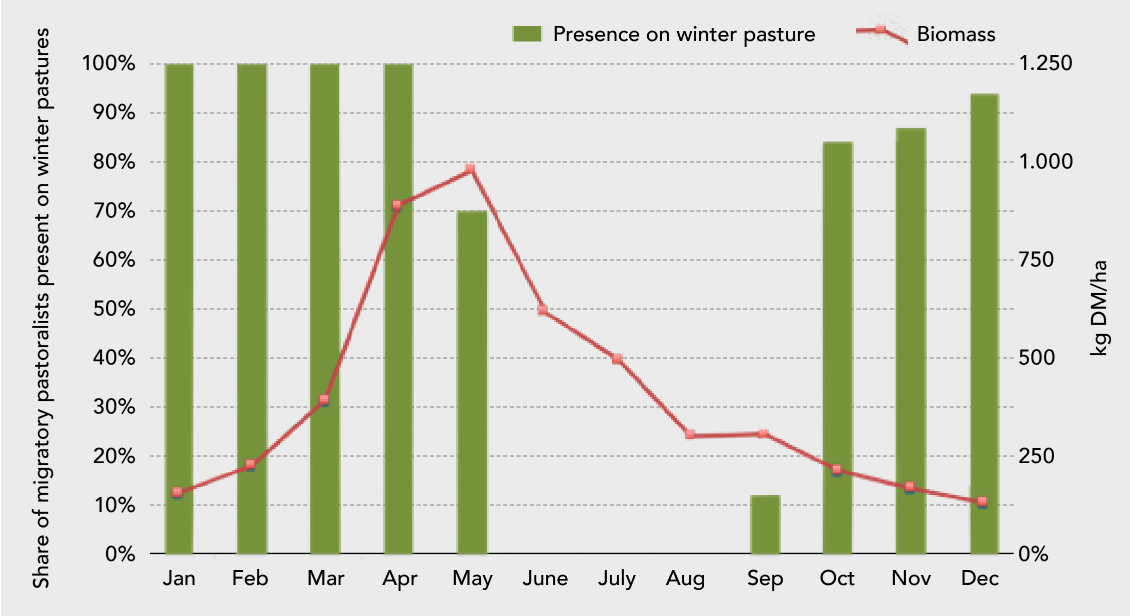
The Savory Institute (2018) holds that overgrazing occurs either because grazing periods are too long or recovery periods are too short. The best way to avoid overgrazing is therefore to plan recovery periods and let those determine grazing periods. In order to **plan for recovery periods**, one need to decide how long animals will stay together in one place, how big that place will be and where they will move next and when they will come back.

The creation of **paddocks** is the instrument for achieving this. As paddock numbers increase, stocking densities increase, while the grazing period in each paddock decreases. According to the Savory Institute (2018), land benefits from larger herds, high density and short grazing periods Paddocks can be demarcated by physical or visual barriers, e.g. fences, natural barriers or through seasonal herding and skill-full use of movable poly-wire and drift fences.

Pastoralists currently make no use of physical paddocks in Kakheti (Arabuli 2018, personal communication). The result is long grazing periods, whereby plants are exposed to a second or third bite before they have had time to recover. Moreover, plants that are tolerant to overgrazing tend to dominate while high-quality forage species that are often less tolerant to overgrazing will vanish over time. Overall plant cover is also reduced.

FIGURE 20

Presence and grazing of winter pastures –migrating pastoralists



5.3 Assumptions, methods, biomass availability and off-take

Assumptions

In the following, we show how land productivity may change in the first year, as a result of using a multi-paddock system and the value of this, for a migratory and resident pasture user.

Migratory grazing patterns

Migratory pasture users descend from summer pastures between the September and December. By October the majority (over 80% of pasture users) have arrived on winter pastures. To generalise the grazing pattern for this profile, we assume that winter pastures are subject to grazing from October until end of May when pastures users migrate for summer pastures (Figure 20).

Biomass availability

Figure 20 also shows the biomass per ha in Dedoplistskaro[14], for the year of 2016, which is a fairly representative year in terms of precipitation and rainfall. As of end of February, biomass increases exponentially and peaks in May, after which it declines. This figure and the metrological data presented in Chapter 2, suggest that the growing season begins some time in February and ends in November. This aligns closely with the findings of NACRES (2013) for Vashlovani National Park. From the perspective of holistic planned grazing, it is of interest to incorporate recovery periods in a paddocking system as soon as the growing season begins and until the onset of the slow growing season (Dudu 2018, personal communication, Shelton 2018, personal communication) .

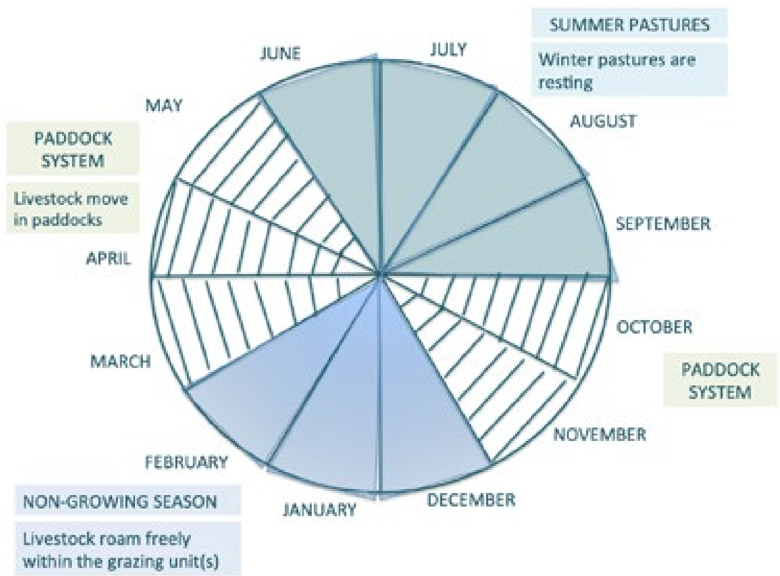
Use of paddocks

In calculating the impact on forage productivity, we consider the first year and assume that the pastoralist does not adjust animal numbers, nor the size of the grazing unit, but accounts for when and where the animals graze using paddocks. In particular, it is assumed that migratory pastoralists implement paddocks from early March when the growing season is in full swing, until he leaves for summer pastures in the end of May. When back from summer pastures, the pasture user incorporates paddocks in October and November (slower growing). This principle is illustrated in Figure 21. In the non-growing season, we simulate "free play" i.e. no use of recovery periods, although it may also be of inter-

[14] *Satellite imagery from the PROBA-V sensor of the Copernicus Global Land Service program was used to assess the productivity of winter pastures in Kakheti. Biomass productivity (in kg DM/ha) is calibrated for the conditions of the case study by means of spatially explicit biomass estimates obtained from ground samples undertaken by E.C.O. institute in Tusheti in 2016 (Kirsmeir 2018). More information on the methodology is found in Appendix 2.*

FIGURE 21

Multi-paddock adaptive grazing as applied to a migratory pastoralist



est to use paddocks in the non-growing season to balance the nutritional intake of livestock, as argued in the discussion of this chapter.

Forage recovery periods

Forage recovery rates vary according to the prevailing weather, species genetics, soil health, soil moisture and grazing severity. The latter factor can be controlled by the pastoralist using paddocks. Savory Institute (2018) use the concept of light, moderate and heavy grazing, to distinguish grazing intensity. Generally speaking, light grazing refers to a situation in which 40% of the green biomass is grazed in a given paddock, 60% for moderate grazing and 80% for heavy grazing (Savory Institute 2018).

The recovery rate of forage resources dictates how many paddocks are needed. In the absence

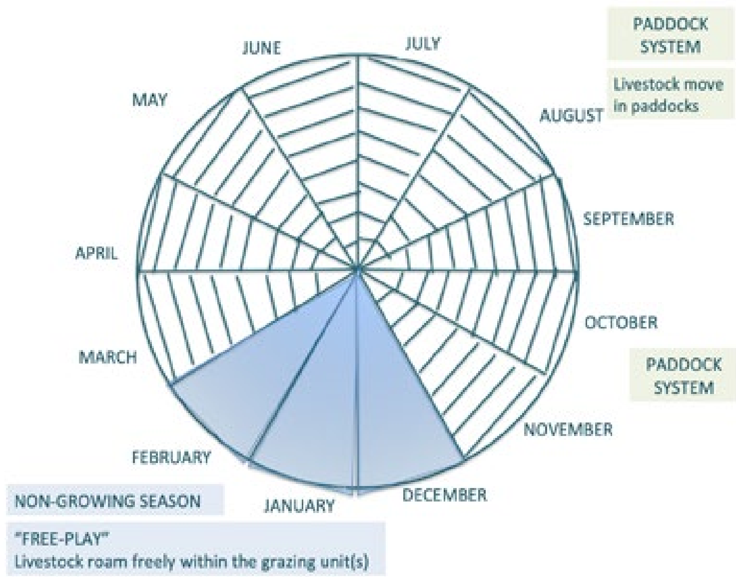
TABLE 14

Input parameters and assumptions used in biomass modelling scenario

Assumptions	Model parameters
Use of paddock, migratory pastoralists	1st March to 30 May & 1st of October – 30th November
Use of paddock, resident pastoralists	1st March to 30st of November
Grazing period per paddock	3 days
Forage recovery period	30 days in spring, 60 days in autumn
Supply of forage DM	Average: 600 kg/ha in spring, 300 kg/ha in autumn
Daily consumption per sheep unit	1.5 kg DM /sheep unit/day
Price per kg of hay	0.21 GEL/kg

FIGURE 22

Multi-paddock adaptive grazing as applied to a migratory pastoralist



of field experiments and knowledge about true recovery rates of Kakheti winter pastures, we use data from similar environment in Turkey, Çanakkale, in the Biga region that has the same climate classification ("Csa") as that of Kakheti, according to Köppen-Geiger[15] and Peel et al., (2007), Çanakkale has recovery periods of about 30 days from March to June and 45 days from July to November in the case of light to moderate grazing (Dudu 2018, personal communication). As shown in Table 14, demand for forage from any one paddock is likely to exceed available forage in autumn (approximately 300 kg DM/ha). We therefore use a conservative estimate of a 60-day recovery period for July through to November.

Grazing period in each paddock

Additionally, we use a "safe-rule" of 3 days of grazing periods in each paddock, as there is little danger that plants will be overgrazed in that case (Savory Institute 2018). Since pastoralists currently make no substantial use of paddocks in Kakheti, real or visual paddocks would need to be created. This is usually done through participatory mapping.

5.4 Modelling and valuing pasture recovery

In the absence of data from an actual field experiment of multi-paddock adaptive grazing in Kakheti, we have used above mentioned assumptions to model how forage production is impacted by the use of paddock systems in Appendix 5 (Equation A5.1 through to A5.13). For the sake of illustration, we have done this with reference to a small pasture user that has a 390 large herd size and 166 hectares of grazing unit under his management. The same set of Equations apply to any pastoralist in Kakheti that has a unit of grazing land under his management.

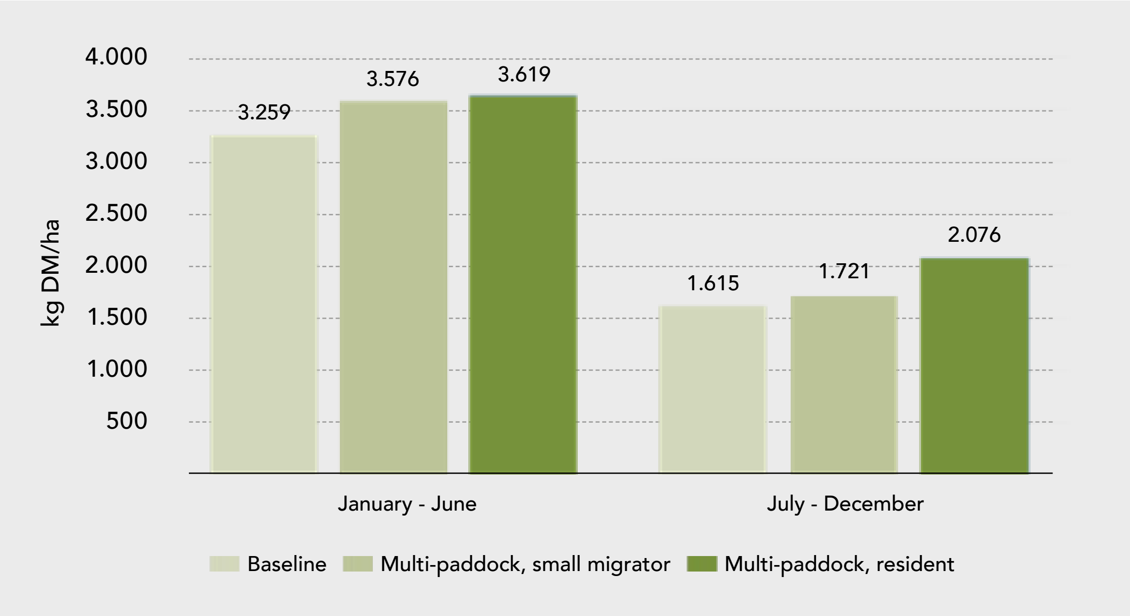
5.5 Migratory pasture users

Over a year, the additional forage generated for a typical migratory pastoralist with a small herd size is in the order of 423 kg of DM per ha for an average year. This corresponds to a 9% increase productivity (see Table 35, Appendix 5). Since all migrating pasture users purchase significant quantities of supplementary feed, the benefit may be valued in terms of the avoided costs associated with the purchase of hay. Selling at 0.21 GEL/kg hay, the avoided supplementary forage costs are in the order of GEL 89 per hectare (Equation 12).

[15] https://en.climate-data.org/asia/georgia/kakheti-1201/ and https://en.climate-data.org/asia/turkey/canakkale/biga-19332/

FIGURE 23

Total dry biomass supply during first and second half of the year, under the BAU scenario and multi-paddock adaptive grazing for the migrator and resident.



Equation 12:

Avoided supplementary forage costs
= 423 kg DM/ha x 0.21 GEL/kg = 89 GEL/ha

5.6 The case of a resident pasture user

In the case of village residents using pastureland for grazing all year round, it is possible to optimize forage recovery by using a paddock system throughout the growing season (Figure 22). We assume that stocking densities on communal village pastures follow those reported in Table 11 (2.5 sheep per ha), e.g. 575 sheep units, on 230 ha of land.

Over a year, the additional forage generated for a typical village pasture user using a multi paddock system is in the order of 788 kg DM per ha, corresponding to a 16% increase over one year. Valued with reference to the selling price of hay, the avoided supplementary forage costs are in the order of GEL 165 per hectare (Equation 13, Table 15).

TABLE 15

Avoided costs on forage spending in the first year of the multi-paddock grazing system

Avoided costs on forage spending	Additional biomass	Avoided cost per ha	Total avoided cost
Small migratory pastoralist	9%	89 GEL/ha	GEL 14'742
Medium migratory pastoralist	8%	80 GEL/ha	GEL 40'700
Large migratory pastoralist	9%	103 GEL/ha	GEL 96'800
Resident pasture user	16%	165 GEL/ha	GEL 38'036

Equation 13:

Avoided supplementary forage costs
= 788 kg DM/ha x 0.21 GEL/kg = 165 GEL/ha

The resulting dry biomass found under the baseline and the multi-paddock adaptive grazing schemes are shown in Figure 23. The benefit of enhanced forage supply, in terms of avoided cost savings on supplementary forage is shown in Table 15 for all of the major pasture user profiles.

5.7 Discussion

Grazing intensity in autumn is 74%, which is above the proper use factor (of 40%). Some species (particularly warm season ones) will therefore have a difficulty with re-growing in autumn. To overcome this, the premise of HPG is to increase biodiversity by improving underlying ecosystem process and soil health, so that it is possible to have both warm and cool season plants promoting longer productivity throughout the year.

Secondly, to overcome shortfalls of forage in the autumn and reduce grazing pressure, HPG also calls for using some paddocks in spring for producing hay that is cut to feed animals in autumn. Recalling that the grazing intensity is very light, 18% in spring, allowing for the harvesting of supplementary forage for the winter.

With regards to other HGP experiences, in Anadolu Meralri HPG learning site in Turkey[16], the carrying capacity increased from 2.8 sheep units per hectare to 4 sheep units per hectare within 2 years of implementing HPG.[17] Teague et al. (2015), (2013) suggest that HPG can permit a doubling of the recommended stocking rate without a decrease in animal or plant production. But these findings have been challenged by Briske et al. (2008), and Hawkins et al. (2017), both of whom suggest that HPG is most likely to provide productive advantages on continuous grazing in mesic environments, whilst offering fewer or no such benefits in more arid rangelands. Its appreciation by livestock managers may be more related to the level and care of management and monitoring which the system imposes, rather than to vegetation productivity gains alone (Budd and Thorpe 2009, Teague et al. 2013).

Whether the assumed rates of vegetation recovery required to generate gains from HPG are realistic has not been tested in Georgia. It is therefore recommended that the proposed paddock system is tested with field trials in Kakheti.

5.8 Multi-paddock adaptive grazing versus Holistic Planned Grazing.

Finally, it should be mentioned that HPG is more comprehensive than our focus here, involving a system of management tools addressing ecological, financial and social resilience and can be adapted to any unit of interest, farmers, conservation areas and entire communities. Changes that can come about through HPG are highly context specific, including the adapting herd sizes, changing access to water, making drought reserves, migrating earlier or later to summer pastures, letting animals run on crop fields and grazing in a forest area, etc. The results presented here through application of multi-paddock grazing, is therefore not a reflection of what would happen under full application of the HPG toolbox and principles. The interested reader is referred to the foundations of holistic planned grazing (Savory Institute 2018).

[16] *www.anadolumera.com/*

[16] *https://docs.google.com/document/d/1AZ2LF3tPfobkegIfD12VSIWWALqB1S2WDTDeZqCs-IM/edit#*

06

Sustainable Land Management through annual rotational grazing

Rotational grazing is defined by re-occurring periods of grazing, rest and deferment (Heitschmidt and Taylor 1991). In slow-moving rotational grazing, the grazing area is divided into two or more pasture units. Using experimental evidence from Vashlovani protected area (VPA), in the following we consider the case for using slow rotational grazing to recover rangeland productivity in Dedoplistskaro.

6.1 Background on the experimental field data

As part of the UNDP/EU project "Sustainable Management of Pastures in Georgia to Demonstrate Climate Change Mitigation and Adaptation Benefits and Dividends for Local Communities (UNDP/EU)", NACRES undertook long-term enclosure-based experiments from autumn 2014 to autumn 2016 to understand the impact of grazing on winter pastures in Dedoplistskaro.

Four exclosures were built within Vashlovani protected area and the first set of data was gathered and analysed in autumn 2014. The sites for the grazing exclosure experiment were chosen in areas where sheep graze during the entire winter season. The vegetation cover of these winter pastures is typical of the semi-arid zone, such as *Artemisia lerchiana, Artemisia lerchiana + Salsola ericoidis,* and *Artemisia lerchiana + Bothriochloa ischaemum*. Four control plots were chosen for monitoring purposes in proximity to the exclosures. Both exclosures and control plots were 100 square meters (10 x10 m) in size.

In order to assess the impact of the exclosures on biomass productivity over time, we assess the relative difference in biomass availability on exclosure and control sites at the same moments in time. It should be kept in mind however, that the "control" plot may be subject to more or less grazing from one year to the other and so the difference in biomass between the

TABLE 16

Percentage increase in total biomass productivity (brown and green) in the exclosure relative to the control plot

Dry matter biomass (DM/ha) from NACRES in exclosures relative to the control plots from autumn 2014 to autumn 2016.	**Artemisia lerchiana + Bothriochloa ischaemum**	**Artemisia lerchiana +Salsola ericoidis**	**Artemisia lerchiana**	**Residents**
Spring 2015	After 7 months	65%	69%	103%
Autumn 2015	After 1 year	52%	85%	203%
Spring 2016	After 1.5 years	30%	325%	201%
Autumn 2016	After 2 years	49%	409%	449%

FIGURE 24

Biomass differential between grazed land (control) and exclosure, protected from grazing from autumn 2014 to autumn 2016

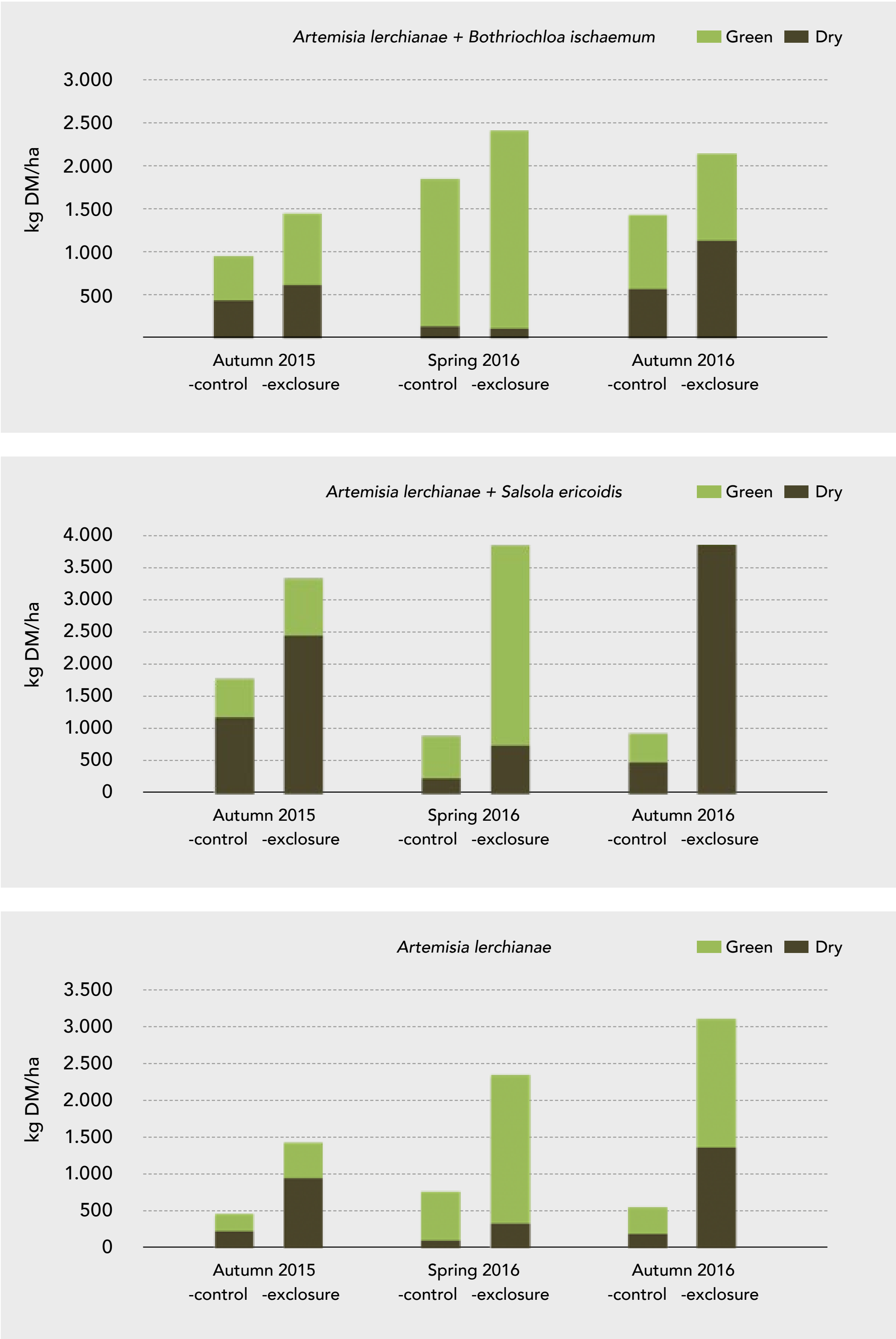
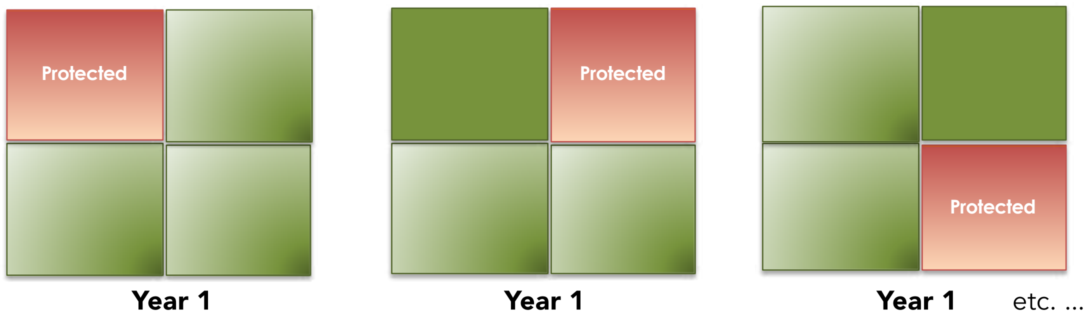


FIGURE 25

Annual rotational grazing protocol



exclosures and the grazed plots, is not a perfectmeasure of how much more biomass may be generated over time as a result of keeping a plot protected.

From Figure 24 (see page 53), it can be seen that already 7 months after an exclosure has been installed there is a profound impact on forage productivity. From autumn 2014 to spring 2015, forage availability increased by over 100% for *Artemisia lerchiana* and 65% and 69% for respectively *Artemisia lerchiana + Bothriochloa ischaemum* communities within the exclosures relative to the control plots (Table 16).

There is also evidence that leaving a site ungrazed for more than a year can allow for further recovery of biomass, in the case of *Artemisia lerchiana + Salsola ericoidis* s *Artemisia lerchiana*. The results are less convincing for *Artemisia lerchiana + Bothriochloa ischaemum*. Considering the forgone benefits of not being able to graze within the exclosure, the evidence is not strong enough for recommending exclosure periods that are longer than one year (Table 16).

6.2 Valuing annual rotational grazing, methods

To assess the impact of introducing long-term rotational grazing practices on winter pastures within Dedoplistskaro we use the example of a small migrating pastoralist leasing 166 ha of pastureland and owning 390 sheep units. Of this land, we assume that ¼ is within an exclosure for one year. The following year another ¼ unit will be closed-off (Figure 25). Over a 4-year period,

TABLE 17

Pasture management characteristics for a small migratory pasture user

Assumptions, pasture user 1	Continuous grazing (baseline)	Annual rotations
Hectares subject to grazing in any one moment in time	166	125
Share of protected land	0%	25%
Hectares protected	0	42
Sheep units	390	390
Stocking density	2.35	3.13

TABLE 18

Absolute land productivity in the exclosure, grazed site and the whole grazing unit, by vegetation type

Autumn dry matter biomass (DM/ha) from NACRES (after 1 year)	Grazed site	Exclosure	Difference (exclosure)	Difference (whole grazing unit)*
Artemisia lerchiana + Bothriochloa ischaemum	959	1457	+52%	+13%
Artemisia lerchiana + Salsola ericoidis	1794	3321	+85%	+21%
Artemisia lerchiana	475	1438	+203%	+51%

the entire grazing unit of 166 ha will therefore have rested for at least one year. At any moment in time, 42 ha will not be available for grazing (Table 17). The implications of having one-year exclosures on overall land productivity for the tree pasture types, is shown in Table 18.

In evaluating the potential benefits from enhanced biomass productivity from rotational grazing, we consider the impact across *Artemisia lerchiana + Bothriochloa ischaemum, Artemisia lerchiana + Salsola ericoidis* s *Artemisia lerchiana* pasture types found in Dedoplistskaro.

Since the NACRES biomass measurements were undertaken in November, they are a good approximation of the forage that may be available during the non-growing season, under the continuous grazing and rotational grazing experiments. Since all pastoralists purchase supplementary forage during the non-growing season, the additional forage generated as a result of the rotational grazing experiment, may be valued in terms of the avoided costs of purchasing supplementary forage.

Over a 5–year period, the net present value benefits of implementing rotational grazing may be estimated as follows:

Forage supply in any one-year t, is a function of the area that used for grazing in the current year t less the area that is protected in year t, as well as the size and productivity of the area that was protected in the preceding year (t -1):

Equation 14:

$$\textbf{DM Forage supply}_{\text{rotation } t} = (\text{area}_{\text{grazed } t} - \text{area}_{\text{protected } t}) \text{ x } \text{DM}_{\text{grazed } t} + (\text{area}_{\text{protected } t\text{-}1} \text{ x } \text{DM}_{\text{protected } t\text{-}1})$$

Whereas in the case of the continuous grazing, the forage supply is only a function of how much land can be grazed at any moment in time, and the productivity of that land:

Equation 15:

$$\textbf{DM Forage supply}_{\text{baseline } t} = \text{area}_{\text{grazed}} \text{ x } \text{DM}_{\text{grazed } t}$$

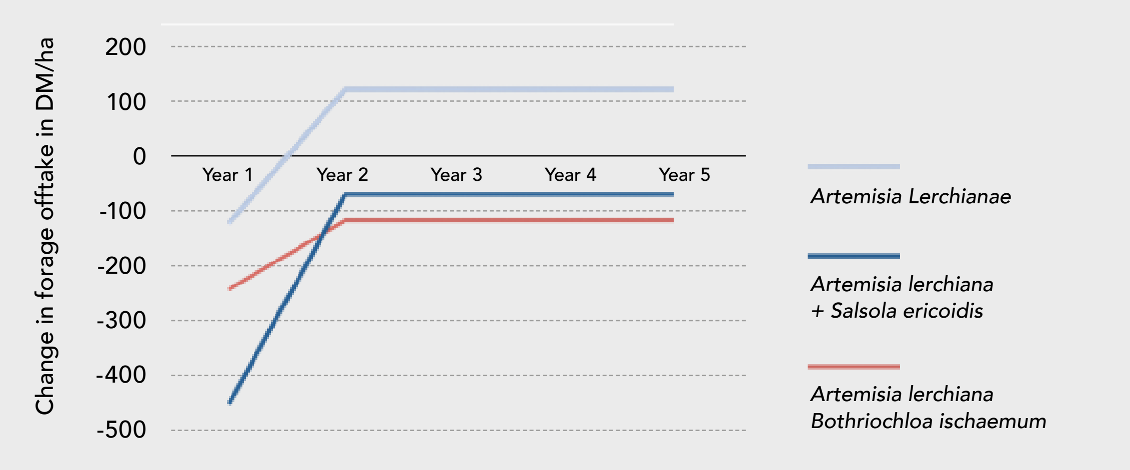
The Net Present Value benefit of any additional forage generated over a five-year period, from the rotational grazing may thus be estimated as the change in the available forage supply over a five-year period, discounted using the real interest rate (r):

Equation 16:

$$\textbf{NPV} = \sum_{t=0}^{4} \frac{\text{DM forage supply}_{\text{rotation},t} - \text{DM forage supply}_{\text{baseline},t} \times \text{Price x PUF}}{(1+r)^t}$$

FIGURE 26

Change in forage off-take, by vegetation type, as a result of implementing annual rotational grazing



Where r=4% and P is the price (0.21 GEL) of purchasing 1 kg of hay. Whilst there is more dead forage in the autumn, for simplicity we assume a Proper Use Factor of 40% for all standing forage whether green or brown. As explained earlier, the carrying capacity of the land is maintained if animals graze no more than 40% of standing forage.

As of the second year, one may also appreciate the impact of grazing management strategy s (*rotation or continuous grazing*) in terms of the sheep numbers that can be carried through the non-growing season, which is assumed to last 90 days:

Equation 17:

$$\textbf{Sheep units}_s = \frac{\text{forage supply}_s \times \text{PUF}}{\text{C x 90 days}}$$

FIGURE 27

Comparison of available biomass under rotation and continuous grazing on three vegetation types for migratory households with small herds.

(Percentages indicate the change in biomass in year 2 when the rotation scenario is implemented)

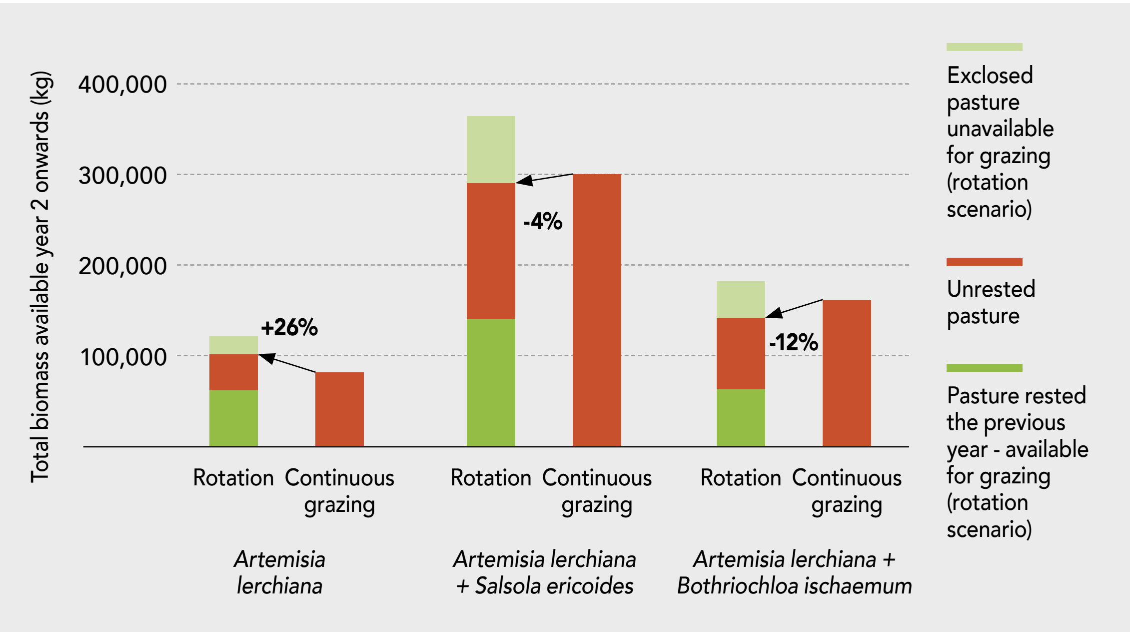


TABLE 19

Sheep units that can be supported through the non-growing season, by grazing system and vegetation type **As of second year, when the additional biomass from the first exclosure can be enjoyed.*

Sheep units that can be supported through the non-growing season	Continuous grazing (baseline)	Rotational grazing*	Difference
Artemisia lerchiana + Bothriochloa ischaemum	472	415	-12%
Artemisia lerchiana + Salsola ericoidis	882	850	-4%
Artemisia lerchiana	233	293	26%

Where C is consumption. As in the preceding chapters, it is assumed that each sheep unit consumes 1.5 kg of DM per day.

6.3 Results, the value of annual rotational grazing

Figure 24, shows that if a pasture user decides to implement rotational pasture scheme on pastures that is under his management, he will experience a loss in forage supply in the first year (relative to the baseline situation of continuous grazing) for all of the three pasture types. This is because his effective grazing area is reduced and he cannot benefit from the improved forage productivity in the first year. As of the second year, the additional biomass that has been recovered in the exclosure more than compensates for the reduction in the effective grazing area in the case of *Artemisia lerchiana* pastures, allowing total off-take and stocking rates of sheep units to increase beyond Business as Usual (see table 19). Encouragingly, *Artemisia lerchiana* is the dominant vegetation type on winter pastures in Dedoplistskaro (Lachashvili et al. 2007).

Figure 27 shows that whilst overall biomass productivity increases for all three pasture types, the effective offtake is reduced for *Artemisia lerchiana + Bothriochloa ischaemum* and *Artemisia lerchiana + Salsola ericoidis* pastures, because a part of the increase cannot be enjoyed as it is found within the exclosure.

Accounting for the value of the surplus biomass (in terms of avoided supplementary forage costs) the Net Present Value benefit over 5 years of using annual rotations on *Artemisia lerchiana* pastures, for a small migrating pastoralist is in the order of 26 GEL per hectare pastureland, or GEL 4280 for the whole pasture unit (Table 20). For other pasture types – the increase in biomass does not compensate for the reduction in the grazing unit. Consequently, whilst the pastoralists would still be contributing to Land Degradation Neutrality by using annual rotations, there is a significant opportunity cost associated with not being able to use the part of the land that is being protected. As a result, they would be worse-off within a 5-year time horizon (negative NPV), as shown in table 20.

TABLE 20

Net Present Value benefits from annual rotational grazing

Pasture species	NPV over 5 years (GEL)	NPV per ha (GEL)
Artemisia lerchiana + Bothriochloa ischaemum	-9'756	-59
Artemisia lerchiana + Salsola ericoidis	-9'292	-56
Artemisia Lerchiana	4'280	26

Appendix 6 shows the data underlying the results presented here.

6.4 Discussion

Over a 5-year time horizon, the Net Present Value of annual rotations is in the order of -59 GEL/ha to +26 GEL/ha, depending on the vegetation type. Any migrating pasture user, dedicating approximately one quarter of his pastureland to a yearly exclosure can expect an income gain/loss in this range. Variation in meteorological conditions, and other factors influencing biomass productivity, may however alter NPV outcomes.

We have assumed that the costs associated with making the exclosure are negligible, although in reality this may not be the case, as it may be difficult for the pasture user to exclude access to pastures by other pasture users when arriving from summer pastures. Furthermore, whilst the results on *Artemisia lerchiana* pastures shows that it is of interest for pastoralists to implement a rotational grazing scheme, they need to wait one year before enjoying improved biomass. The monetary benefits to be enjoyed from the rotational grazing scheme are therefore dependent on land tenure security (subject of Chapter 7).

At present however, 50% of all migrating pasture users neither rent nor own pastureland. Amongst the remaining 50% having some tenure security, 26% use subleasing arrangements which can be ended at any moment in time. At present therefore, the institutional and legal environment is not conducive to rotational pastures. The same conclusion is likely to hold true on village pastures, as only 15% of villagers own or rent any pastureland. Rotational pasture schemes lend themselves well to implementation on communal village lands however, as proven elsewhere, e.g. in Jordan (Westerberg and Myint 2015).

However, annual rotational grazing is not recommendable on village pastures that are dominated by *Bothriochloa* (as described in Chapter 2), a species, which is unpalatable when dry (Gintzburger 2012) or when it reaches the flowering stage. NACRES (2013), therefore recommend that Bothriochloa is continuously grazed before reaching the flowing stage, or following Gintzburger (2012), cut for hay before winter.

6.5 Summary – Land productivity from SLM scenarios and the contribution to LDN

Table 21 summarises the results from the scenario valuations outlined in the previous three chapters. We can conclude that:

- De-stocking during the non-growing season is expensive for all pasture users, and prohibitively expensive amongst small migrating pastoralists. But de-stocking would avoid future land degradation associated with long term stocking rates above carrying capacity.
- Multi-paddock grazing systems may improve land productivity and make pastoralists better off, as of the first year of implementation. Additional forage generated can be cut for hay and used to feed herds in the non-growing season to avoid overgrazing during the non-growing season. But results depend on assumptions about vegetation recovery rates which have not been tested in Kakheti.
- Annual rotational grazing is an effective strategy to contribute to land productivity and land degradation neutrality on winter pastures but, depending on vegetation type, can be costly for pastoralists because of the reduction in their effective grazing area. Economic incentives may be used to compensate and incentivize uptake of rotational grazing. Annual rotations are not recommendable on pastures dominated with *Bothriochloa*, typically village pastures.

Thus, whilst the economic case for SLM is variable from the perspective of the individual pastoralist, all three SLM techniques can be used to regenerate biological productivity and contribute to land degradation neutrality. Finally, it is worth highlighting that one SLM strategy does not exclude another. They can be used in isolation or complementarity to one another, within any one year or from one year to the other.

To do so, pastoral communities should be equipped with the tools and knowledge to estimate and monitor forage resources, discern vegetation type, adjust grazing patterns, recovery periods and stocking rates accordingly and finally, to understand the advantages, costs and risks of each SLM method.

TABLE 21

Summary of land productivity from SLM scenarios

SLM approaches	Change in forage productivity	Timeframe	Source	NPV/ha from adoption SLM
De-stocking from heavy grazing to moderate grazing	Up to 20%	Within 5-15 years	Holecheck (1999)	N/A
HPG & Multi-paddock grazing / migrator	9%	Within 1 year	Own calculation	89 GEL/ha
HPG & Multi-paddock grazing / resident	16%	Within 1 year	Own calculation	165 GEL/ha
Slow rotational grazing	13%-51%	Within 1 year	NACRES + own calculation	from - 59 GEL/ha to +26 GEL/ha

Survey implementation in the municipality of Gurjaani"

07

Policy frameworks, mechanisms and incentives in support of Land Degradation Neutrality

Georgia has committed to land degradation neutrality as a signatory of the 2030 Agenda for Sustainable Development and through engagement with the Land Degradation Neutrality target setting programme (TSP) of the UNCCD. Land Degradation Neutrality is understood as a state *"whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems"* (UNCCD Knowledge Hub 2020a).

Georgia's national LDN targets, submitted to the UNCCD secretariat in September 2017 by the Ministry of Environment and Natural Resource Protection (MoENRP), include:

- The integration of LDN principles into national policies, strategies and spatial planning.
- The afforestation of 1500 ha of degraded forests and rehabilitation of 7500 ha of degraded forests, 60% of the forests are being managed sustainably.
- An increase in the protected area cover to 12%.
- The rehabilitation of degraded land and improvement of the irrigation and drainage system.

In terms of pathways for the implementation of LDN targets and monitoring progress, Huber et al. (2017), highlight the need for using spatial planning processes at the national, municipal and community level. Spatial planning however, cannot be applied to pastures if local authorities do not have adequate jurisdiction over pasture designation. The underlying property rights framework therefore needs to be revised.

Additionally, complementary incentive structures may be applied to ensure that land degradation is accounted for in decision making by the general public and policy makers (Huber et al. 2017). In light of the recommendations from Huber et al., (2017) study 'Pilot project on land degradation neutrality in Georgia', the Legal and Institutional Analysis by Robinson (2018) and the results from preceding chapters, we present and discuss the current state of various policy tools and property right frameworks that Georgia can use to achieve its land degradation neutrality targets.

7.1 Mechanisms for issuing leaseholds

As we have seen in Section 2.3, the majority of pastures in Georgia are owned by the government and administered through leasehold contracts by the Agency for State Property (ASP). The leasing process is held by electronic auction at the national level, with pasture allocated regardless of residence and actual use of pastures. This process is inaccessible to many ordinary pasture users, which explains why most users have no formal rights over pasture. In some cases, pastoralists sub-lease, at higher cost, from primary leaseholders for short periods. Private ownership also exists, based on previous laws, but new privatization on pasture is no longer possible. The current leasehold allocation mechanism bypasses the municipality and occurs on a case-by-case basis with no system for overarching pasture management at the ecosystem level. Thus, private users currently have rights but no responsibilities, whilst those using pastures on a collective basis have neither rights nor responsibilities.

Leasehold contracts may include management obligations, but it is unclear whether this is currently the case for ASP-administered contracts. Another pathway concerns leaseholds issued by the APA, which do include pasture management obligations but apply to protected areas only. In rare cases municipalities administer leaseholds on their own land or in category 5 protected areas but the legal mechanisms underlying issuance of new leaseholds by municipalities have been removed.

As we have seen, 27% surveyed households leasing pastures have sub-leases, sometimes of only one-year duration. This undermines incentives to implement sustainable rangeland management strategies and the economic ability to stock at 'moderate' rates. Instead, the incentive is logically one of *harvesting as much as possible today, because I do not know if I will be here tomorrow*. High leasing fees raise the costs of de-stocking, especially for livestock owners with small flocks, who cannot enjoy economies of scale. The ASP has currently imposed a moratorium on the administration of new leaseholds whilst alternatives to the auctioning process are reviewed.

- If leasehold is eventually selected as the main mechanism to allocate winter pastures, the allocation process should dissuade the acquisition of pastures for speculative purposes and sub-leasing, and first and foremost allow existing pasture users to obtain long-term rights. Thus, local residents should have priority and allocation should be administered through a simplified and locally managed procedure by municipalities in the framework of spatial planning (see below).
- Special consideration should also be given to the large population of Azeri nomadic households that use winter pastures in Kakheti, but currently lack rights to buy or rent Georgian farm and pastureland.
- Whilst subleasing arrangements are counterproductive to sustainable land management, their outright prohibition may be excessively restrictive, as subleasing can be a flexible arrangement for people to access pasture at times of need. Speculation can be avoided, for example, by prohibiting sublease fees which exceed those of direct lease, similar to clauses found in some housing markets. Leasehold markets are also crucial. Transfer of contracts between users should be easy and flexible, reducing need for sublease.

7.2 Leaseholds and conditionality

At the level of individual users, the terms of the leasehold contract can be used to improve pasture management. For example, in the Vashlovani Protected Area, leasehold agreements with the Agency for Protected Area (APA) include set stocking rates based on detailed vegetation assessments and obligations to use planned grazing strategies in partnership with park authorities (NACRES 2015). The assessments consider a large range of factors, including soil composition and structure, land exposition and slope, and vegetation characteristics such as nutritional value, height and diversity. It is suggested that the experience gained by APA in pasture management planning is applied to other parts of the country. However, whilst this approach will most certainly lead to better managed pastures, the cost-effectiveness of such a 'top-down' approach, may be questioned, to the extent that:

- Undertaking detailed and regular vegetation assessments is expensive, especially if the approach is used throughout the country's PAs. Guidelines for seasonal stocking density based on broad vegetation types could perhaps also be employed without new assessments as the main vegetation types and their productivity is already known.
- More importantly, we fear that this approach undermines pastoralist's ability and motivation to design sustainable rangeland management strategies. More practical 'hands-on' tools exist which empower pastoralists to monitor forage resources, incorporate recovery periods or determine sustainable stocking densities (Savory Institute (2018).
- If livestock owners hold appropriate property rights over pasture, and simple mechanisms to adjust their pasture use from year to year depending on livestock numbers and pasture condition, the need for detailed assessments will be reduced. Improved subleasing arrangements, leasehold transfers and common

property arrangements (see below) can all facilitate this.

- But pastoralists also need long term security over core pasture areas. What is clear from this ELD study is the importance of ensuring that lease contracts are of sufficiently long duration to ensure that pastoralists have sufficient incentives to invest time and resources into sustainable rangeland management practices. The maximum length of pasture leaseholds of 49 years is coherent with this objective but many of the leaseholds dispensed by the APA and ASP are much shorter.

As for areas outside the jurisdiction of APA, the Agency for State Property (ASP), is the issuer of leasehold contracts and therefore responsible for setting terms of pasture use, whilst the MoEPA is responsible for monitoring changes in condition (Robinson 2018).

- It is not clear whether special land management obligations exist for state owned pastureland administered by the ASP. Either way, it can hardly be cost-effective to have leasehold and monitoring responsibilities sitting with two different government agencies. Moreover, such an arrangement does not meet calls (e.g. in Huber et al., 2017) to enhance the mandate and incentives for communities and municipalities to manage their land resources in the context of supporting LDN implementation.

7.3 Leaseholds, compensation measures and information-based incentives

Finally, it is important to highlight that pastoralists engaging in the restoration of pastures are contributing to Georgia's LDN targets, supporting overall ecosystem resilience, food and water security in Kakheti.

- It may therefore be argued that pastoralists should be compensated for their efforts. This could be done for example, through the lowering of leasing fees, conditional upon engagement in specific SLM efforts, such as de-stocking or rotation. Education and capacity building for sustainable land management is also warranted (Huber et al. 2017). Financial resources for training and education could be mobilized through leasehold fees and the restructuring of responsibilities from national to municipal and local levels.
- As advised by Huber et al. (2017), pastoralists engaging in these SLM schemes may serve as community leaders or representatives in local initiative groups working in coordination with competent institutions (e.g. RECC) to facilitate local LDN target setting process and produce LDN monitoring results.

7.4 Common property resource management

Whilst there are ways to improve the current leasehold system, the individualization of pastures may be questioned in the context of mobile pastoral systems and collective herding systems near villages in Kakheti. Typically, rangelands in arid areas are often characterized as common pool resources (Ostrom 1990) due to uneven pasture quality, distribution of water points and salt licks. Numerous experts have argued that in such areas, the ability to move over large areas is a requirement for good pasture management, because it allows livestock owners to exploit spatially and temporally variable resource availability, challenging the practicability of sub-division and individualisation of property rights (Behnke et al. 2011, Coughenour 2008, van den Brink et al. 1995).

Moreover, in this report, we suggest that, whilst de-stocking can help regenerate pastureland, it is not economically feasible for pastoralists with small herds on individually leased pastures. Common property management regimes allow for pooling of resources and therefore a reduction of the fixed costs to individual households of herding.

At the village level, many pastures are *de-facto* commonly managed, as herds are comprised of animals belonging to multiple owners who manage grazing as a group. The lotting of such pastures into individualised parcels makes little sense, and these areas would be good candidates for collective management (Neudert et al. 2017) through common property resource management schemes.

However, there is no evidence that municipalities are able to register pasture at present. Laws would have to change to enable registration of lands to municipalities.

- Until this happens, the lack of legal instruments to delimit and designate municipal pastures to village users for common use is a source of insecurity for resident livestock owners and a barrier to sustainable management. Herds are not confined to pastures, but use any public area for grazing, including sensitive habitats, such as scrubland and windbreaks (Arabuli 2018, personal communication).
- The amplitude of such practices is illustrated by the fact that 74% of village pasture users do not lease or own pastureland (according to the ELD household survey). It means that three quarters of the pastoral population have no power to undertake or enforce sustainable rangeland management practices. Not surprisingly, their objectives can only be one of maximising current/present-day resource use.
- On winter pastures, 50% of pastoralists surveyed do not lease or own pastures. They therefore either use land informally, or herd on the land that is under the leasehold of someone else. In this sense, herding is still collective although the management right stays with the leaseholder.

At the national level, over 400,000 holdings have livestock, yet less than 80,000 have legal access to pastures or meadows. In this context, the possibility of common resource property management on village pastures and perhaps on winter pastures depending on context, should be considered.

7.5 Cooperatives and conditionality

A management mechanism that is being trialled by the government as an alternative to the land leasing arrangement is the allocation of pastures to cooperatives. Starting in 2017, the Cooperatives Development Agency (CDA) funded 29 cooperatives in 21 municipalities under the programme entitled “Rational Use of Pastures and Hay land in High Mountain Regions”. Of the 29 cooperatives, 19 have received land so far. The full set of eligibility criteria are provided in Robinson (2018) but two are worth highlighting: The specific area of pasture should allow for between 1.5 and 4 ha of grazing per head of cattle and the cooperative should commit to double the number of animals owned within 5 years.

- This latter requirement seems prohibitively restrictive, in that the availability of pasture resources and the management regime will determine the animal numbers that the land can support. In line with the recommendations made in this report, pastoralists should rather be equipped with the tools to monitor and manage their herd sizes and movements in accordance with their own objectives and underlying pasture condition.
- That said, cooperative structures, is a promising alternative to land leasing arrangements, reflect the reality that herding is often practiced as a collective activity in Georgia.

The MoEPA will assess the programme in the future and results will inform decision making about future direction for pasture management.

7.6 Municipal Spatial Planning

The role of municipalities in administration of pastures within their boundaries is important, as decentralisation to this level is one possible way in which issues with leaseholds and collective pasture use might be resolved. One mechanism which has been identified to unify pasture use zoning, allocation, management and monitoring at the local level is the spatial planning procedure, for which the legal basis is currently being introduced and which is being piloted in a small number of municipalities. For example, Akhmeta municipality directly administers leaseholds over pasture in the Tusheti Protected Landscape. However, few municipalities have this level of jurisdiction over pastures.

Spatial plans include the definition of areas and boundaries of different land use types, based on zoning into urban, recreational, agricultural and transport areas. Spatial planning is used to make decisions on boundary changes or re-allocations between land use designations, the status of infrastructure projects and priorities for repair and for new projects. The aim of the planning process is to achieve environmentally sound outcomes, incorporating Georgia's international commitments and LDN neutrality targets.

For example, planning for LDN implies the production of land use maps, including the demarcation of areas subject to unavoidable land degradation (losses) and priority areas for land restoration or rehabilitation (wins). The definition of priority areas for rehabilitation measures should ensure that land is available to compensate for land degradation (Huber et al. 2017).

However, as highlighted in (Robinson 2018), **spatial planning cannot meaningfully be extended to pastures whilst the ASP as the manager of state-owned pastures**. Municipalities or pastoral user groups will need to have jurisdiction over pasture designation, allocation or pasture management activities before municipal spatial planning can be used effectively as a mechanism to attain LDN. This would be essential whether the tenure system was that of a leasehold, in which case municipalities could administer these, or CPRM, in which case the state or municipality would be the land holder and a legally registered set of users responsible for management.

7.7 Discussion and concluding comments

To conclude, there are obstacles at several levels hindering the sustainable management of pastures, ranging from short-term lease contracts, the inability of municipalities to designate land for village pastures, and overlapping responsibilities amongst different government agencies, based far from the field site.

In the light of this, stewardship of pasture resources by their users may be enhanced by improving tenure security through long-term **accessible and affordable** leaseholds, or through use of structures such as cooperatives and Common Property Resource Management schemes, that allow for the pooling of resources.

Pastoralism in Kakheti is associated with economies of scale, meaning that the average cost per unit of production decreases as the herd size (pastoral enterprise) increases. Allocating land through leaseholds alone will therefore marginalise small pastoral farmers. If this is something that the Georgian government would like to avoid, the individualization of pasture should be strongly reconsidered.

Moreover, the high fixed costs associated with leasehold makes it prohibitively expensive for smaller herders, comprising of at least 50% of the migrating population, to implement destocking measures, which is one way to regenerate vegetation resources, as shown in this study.

Various measures can be employed to incentivize sustainable land management, for example by rewarding pastoralists for engaging in the regeneration of pastureland through the lowering of pasture lease fees and discouraging subleasing through by prohibition of sublease fees above those of direct lease. Training and capacity building of pastoralists in the monitoring of pasture resources, calculation of sustainable stocking densities and integration of recovery periods within multi-paddock or annual rotational grazing plans, may also be pertinent.

According to the authors of this study, the empowerment of pastoralists and cooperatives should be favoured over "top-down" measures, stipulating maximum stocking densities for example. Pastoralists piloting SLM measures could furthermore work in coordination with competent NGOs to facilitate local LDN target setting process and produce LDN monitoring results.

08 Conclusion

This study has explored the scope for regenerating pastureland in Kakheti, a region that is affected by climate change and increasing demand for scarce winter pastures, compromising Georgia's commitment to become land degradation neutral by 2030.

This study has shown that there is evidence of overstocking, as winter pastures can support slightly over one sheep unit per hectare during the slow-growing season, whereas current stocking densities are double this number (although it should be emphasised that in winter many animals are partially fed on supplementary fodder). Literature suggests that de-stocking from heavy to moderate grazing levels may result in increases in pasture productivity of 20%. But analysis suggests that this is a costly strategy, and that only very large pastoralists (>2000 sheep units) would be able to continue to earn a positive net-income after de-stocking. In the absence of high land rental costs however, (for example if fees were reduced or leaseholds replaced by collective management schemes) de-stocking, would become more feasible. Thus, de-stocking is likely to be unsuccessful in the face of high land lease costs and insecure tenure.

The ELD survey supporting this study revealed that 72% of all pasture users in Kakheti have no formal claim on winter pastures, whether through leases, sub-leases or ownership. The leasehold and sublease arrangements concerning the bulk of the remainder, tend to be short term. Thus, livestock owners are most likely to perceive the direct impacts of de-stocking on their household economy and not the potential long-term benefits of reduced stocking densities and forage recovery.

Whilst de-stocking is likely to be an unpopular policy measure, there are other pasture management options that may be explored. In particular, some practitioners and scholars emphasize that it is not the number of animals per unit area that matters, but the timing of their moves. Following the principles of Holistic Planned Grazing, for example, overgrazing occurs because animals are left to graze for too long and return too soon to the same areas. By sub-dividing large grazing areas into several paddocks, animals can be moved from one paddock to another within a few days, allowing the paddock that has been grazed to recover by the time that the animal return. Using this approach, and experimental data from Turkey on pasture recovery rates, our study suggests that land productivity of winter pastures can increase by 9% to 16% in the first year alone in Kakheti, worth 89 to 165 GEL/ha/year in terms of avoided supplementary forage costs.

Finally, experimental results from winter pastures in Dedoplistskaro, show that annual rotations which allow for the protection of a part of the grazing pasture, will also permit the regeneration of pasture resources. Assuming that one quarter of a grazing unit is closed off each year, biological productivity on that unit will increase by 13% to 51% depending on vegetation type. However, over a 5-year period this can be a costly strategy for pastoralists to adopt because 25% of land cannot be grazed is closed for grazing each year. Thus, annual rotational grazing is only likely to be successful if pastoralists have long-term tenure over the land where the rotations are practiced and are awarded a small compensation for their environmental contribution to fighting land degradation.

To summarise, there are several ways to contribute to land degradation neutrality through sustainable pasture management, but no single golden rule can be advised. The SLM strategies all merit being tested in Kakheti. **But fundamentally it is important to first and foremost address the underlying policy failures, which are hindering pastoralists from accessing land formally and are limiting municipalities' mandates to manage, improve and conserve village pastures.**

In particular, as the pastoral system in Kakheti is largely migratory, it should also be questioned whether individualised rangeland access is an advisable policy strategy. Mobility is important in the context of arid and semi-arid rangelands where there is uneven pasture and water resource distribution and high climate variability over time. From the perspective of the pastoral household, there is also an economic case for pooling resources, such as shepherding, machinery and access fees for land, to lower the costs associated with revenue generation, whether it be the production of milk, cheese, wool or lambs. If pastoralists are enjoying economies of scale and secure tenure, the SLM strategies evaluated above will be perceived as less risky and more profitable. **Land Degradation Neutrality therefore, can only be effectively pursued by addressing institutional and legal frameworks alongside with the uptake of sustainable land management strategies.**

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Appendix 1: Defining the LDN Baseline

In order to evaluate the contribution of a land use practice to land productivity and land degradation neutrality as a target, it is necessary to define a baseline. Such a baseline needs to be tailored to the specificities of the region and problem at hand (Huber et al. 2017). Our starting point for defining an appropriate LDN baseline is the evaluation of the main factors limiting grassland productivity, namely temperature and precipitation. If other factors are constant (e.g., grazing intensity, pests) the productivity of grasslands is largely determined by the availability of water and temperature conditions.

For Kakheti, we assume that for any given year, the closer monthly temperature and precipitation are to long-term averages, the likelier it is that the grassland productivity of that year can be considered "typical" or "representative".

In Figure 26, we have determined the deviation of the monthly precipitation and temperature patterns for the years 2014, 2015, 2016 and 2017 from the long-term means of the same variables between 1960-1990. For precipitation it can be observed that year 2016 is closest to typical precipitation conditions. The deviation of precipitation in slightly positive from January to April. For the months of September to December the precipitation values match well the long-term values with an average deviation below 20mm. In the case of temperature, year 2015 was found to be the best analogue to long-term conditions.

It may therefore be concluded that 2015 and 2016 are the years that best mimic the typical climatic condition in Kakheti, for temperature and precipitation respectively. The biomass productivity in grasslands for these years is the

FIGURE 28

Comparison of precipitation and temperature monthly values from the long-term means in Kakheti for the years 2014, 2015, 2016 and 2017

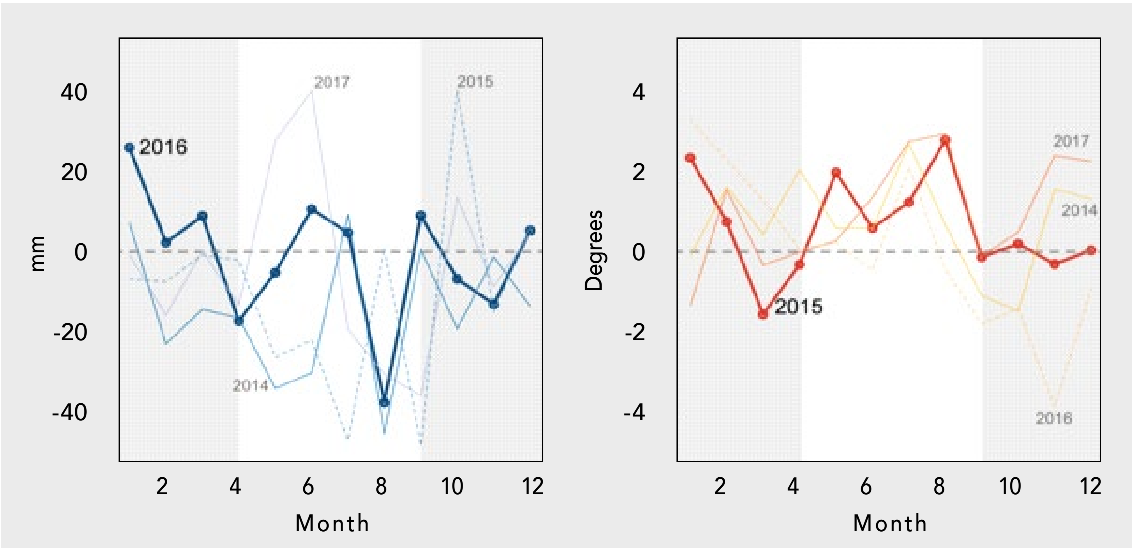
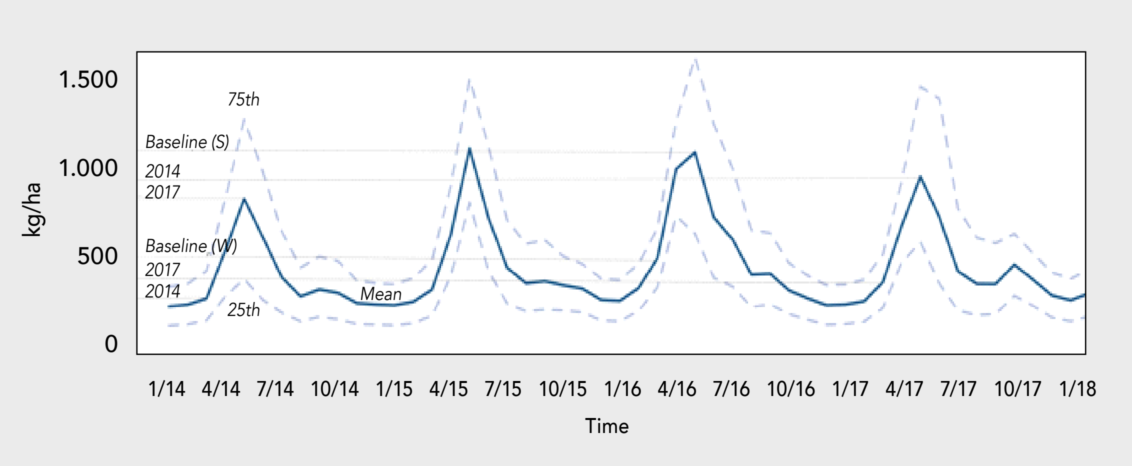


FIGURE 29

Estimates of 25th, 75th percentile and mean monthly biomass in the grasslands of Dedoplistskaro for the years 2014, 2015, 2016 and 2017



highest within the 2014-2017 period and resemble the productivity expected in a "typical" year. This is verified to large extent in Figure 2 showing the monthly evolution of biomass in Dedoplistskaro.

Overall, the years 2015 and 2016 present a higher density of biomass than the years 2014 and 2017. For example, the "biomass peak" taking place in May 2016 (Baseline (S) in Figure 29) is higher than those observed in the same period of 2014 and 2017, but similar to that of 2015. The same is observed for the biomass values of March (Baseline (W) in Figure 29). **For the purposes of this report, we have therefore used 2016 as the baseline year for primary productivity.**

Appendix 2: Biomass calibration for Kakheti

For the estimation of vegetation abundance across the region we used the Leaf Area Index (LAI) data from the PROBA-V satellite, available since January 2014 at a 300 metre resolution for the months of July of 2016 and August 2017. The product provides a 10-day time series of measurements which were aggregated as monthly means.

The Leaf Area Index is a proxy indicator of vegetation abundance, but in order to convert it to a physically meaningful metric such as standing biomass, it must be calibrated using ground data. For this purpose, we used ground measurements taken by the ECO institute in the national park of Tusheti in Kakheti in July 2016 and August 2017 (provided by GIZ). We used the resulting relationship between LAI and biomass to scaling-up these results to the whole of the Kakheti region. An existing biomass map already existed for Tusheti National Park, also created using relationships between remotely sensed LAI (from the Sentinel satellite) and ground measurements (GISLab 2016). Thus, we also compare our own results for that area with those in this map.

The result of the correlation analysis is shown in panel A of Figure 30. An exponential relationship between LAI and biomass may be noted (similar to that found in GISLab (2016)) as well as a systematic underestimation of about 75 kg/ha when using the exponential function relative to the ground-truthed data. Panel B shows the residuals of the fit.

Figure 30 shows how biomass estimates are obtained by calibration of the remotely-sensed vegetation indicator with field samples (a total of 28 of them).

FIGURE 30

A - Correlation results of LAI and the ground-truthed biomass data from Tusheti.
B - Residuals of the exponential fit.

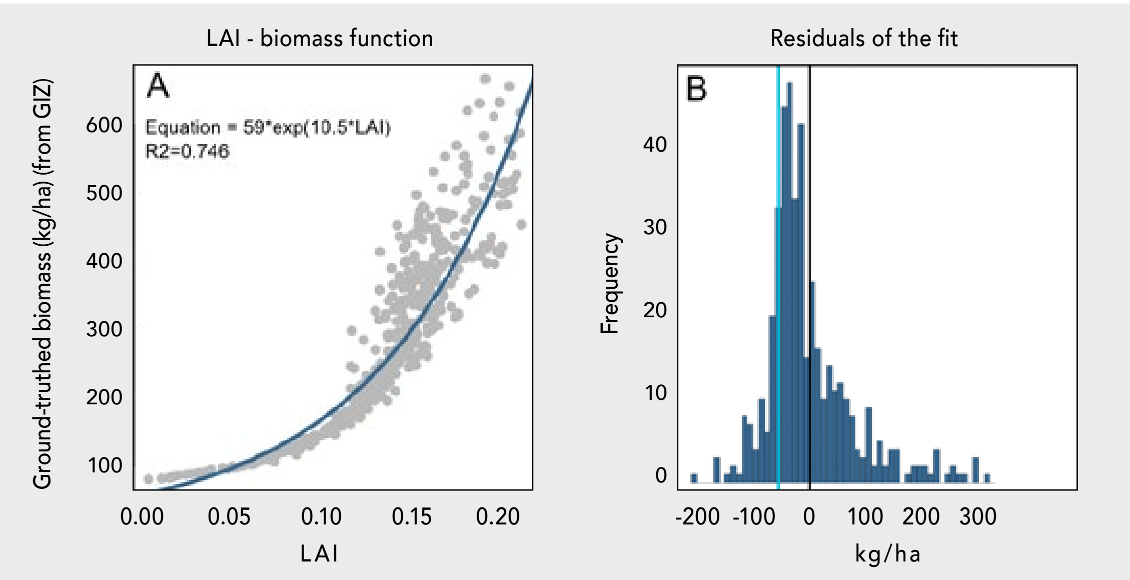
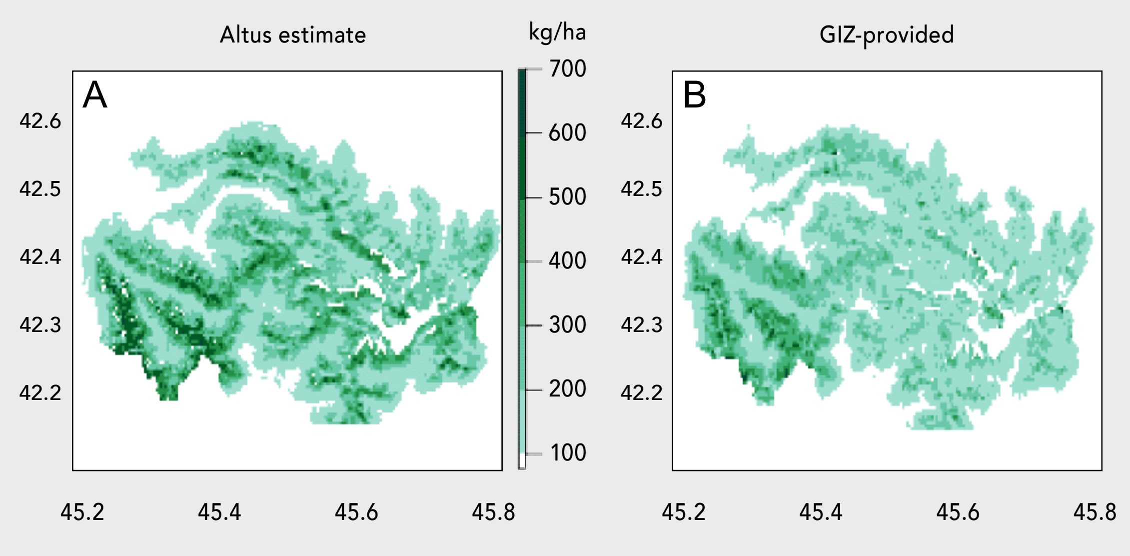


FIGURE 31

Biomass productivity in kg/ha for Tusheti. GISLab (GIZ) and Altus estimates
A - Altus estimate B - GisLab



In order to account for the systematic deviation of the biomass results derived from the exponential function, a correction factor of + 75 kg/ha has been applied to our biomass estimations.

Based on our calibration, estimates of July 2016 biomass patterns for Tusheti are shown in Figure 31, panel A, relative to the original estimations provided by GIZ (panel B).

Although the biomass map was produced for the whole Khaketi region, it was based on field data only from the mountainous north. To test the robustness of our results (see Tables 22 & 23), we also compare the biomass estimates obtained from the calibration exercise with measurements undertaken by NACRES for winter pastures in Dedoplistskaro (Lachashvili 2015, 2016). The location of the points used for

FIGURE 32

Spatial distribution of biomass in grasslands below 1700m elevation in Kakheti (winter pastures)

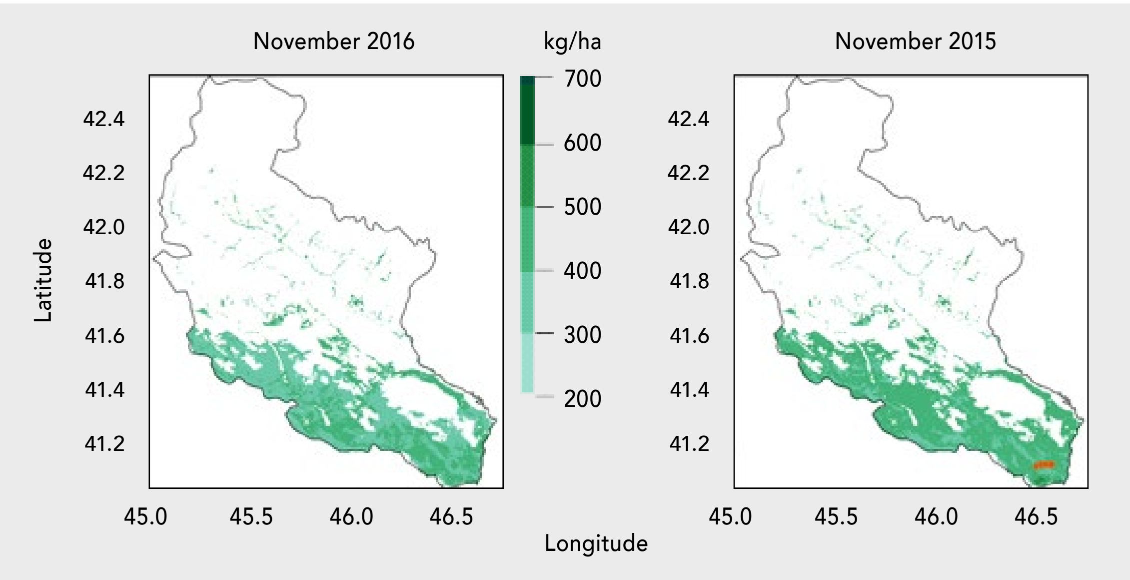


TABLE 22

Biomass estimates from NACRES field experiments November 2015 and calibrated estimates

Dominant species	NACRES total biomass in control plots for November 2015	Model estimates for November 2015	% difference to estimate
Artemisia lerchianae	474.5	641.4	35%
Artemisia lerchianae	792.8	695.7	-12%
Artemisia lerchiana+Bothriochloa ischaemum	959.4	744.0	-22%
Artemisia lerchiana+Salsola ericoidis	1794.0	661.2	-63%

comparison are shown in orange. The biomass results from the fitted function are shown in Figure 32 for the months of November 2015, November 2016 and July 2016.

The comparison of results reveals that more often than not our estimates are lower than those from Lachashvili 2015 for November 2015. While for some plots the deviation of our estimates are in the order of -22% or less, for others the difference can be substantial. For November 2016, plots dominated by *Artemisia lerchianae* show a fair agreement with our estimates while for the other plots the deviations are large, though consistently below what is reported in NACRES. In particular, the plots with *Artemisia lerchiana+Salsola ericoidis* and *Artemisia lerchiana+Bothriochloa ischaemum* are those where the deviations are the largest.

Although we were able to approximate biomass for the winter season without adequate ground sample data across time and space, the method used can be further improved to in order to account for more specific seasonal dynamics of grasslands. Given the large heterogeneity of biomass in grasslands, it is hard to conceive of a generalized method for estimating biomass across the region of Kakheti, which would resolve such variation, in particular in the light of the limitations mentioned beforehand. Nevertheless, we have made a first step to estimate biomass on all of the grasslands of Kakheti around the year, and in some cases our estimates are not so far off from those available in Lachashvili 2015 & 2016. This is encouraging in the measure that it suggests the possibility of estimating biomass over large geographical areas with limited information.

TABLE 23

Biomass estimates from NACRES field experiments November 2016 and calibrated estimates

Dominant species	NACRES total biomass in control plots for November 2016	Model estimates for November 2016	% difference to estimate
Artemisia lerchianae	563.9	626.3	11%
Artemisia lerchianae	640.6	650.4	1.5%
Artemisia lerchiana+Bothriochloa ischaemum	1436.1	642.6	-55%
Artemisia lerchiana+Salsola ericoidis	944.34	637.5	-32%

Appendix 3: Household sampling frame, survey design, survey coverage, cluster analysis and pasture user profiles

Population of farming households and livestock numbers in Kakheti

The Agricultural Census of 2014 (GeoStat 2016), the updated census of 2016 (GeoStat 2017) and data on stock numbers in Dedoplistskaro from the National Food Agency of Georgia (2016), were used to estimate the number of livestock and households in each region. The total number of livestock in Kakheti are taken to be those given by the National Statistics Office of Georgia for the year 2016, with the regional split proportional to the Agricultural Census of 2014. A reconciliation of these numbers and accompanying data tables are detailed in Table 24.

Sample size and target respondents

The number of households in Kakheti that are pastoralists is unknown. There are 88,800 households in Kakheti that have some sort of agricultural activity, including wine making, arable production, fruit growing and livestock rearing (GeoStat 2016). Of the total agricultural land used in Georgia, 38.1% is pastureland or meadow (ibid.). On average, the area of land per household is 1.4 hectares, indicating that this statistic includes properties with small areas of land as well as larger scale livestock operators. However, based on this, an estimate of households within Kakheti that own grazing livestock is 2,877 (taken to be the upper bound of the estimate for number of holdings with at least 10 cows, or 50 sheep units).

A sample size of **350-380 households** was required represent the 88,000 households in Kakheti with 90 to 99 % confidence (Table 25). The large proportion of the sampling effort was dedicated to the municipality of Dedoplistskaro, as the primary destination for wintering of livestock.

TABLE 24

Population of pasture-users and livestock in Kakheti

	Number of households/ holdings	Number of cows	Number of ewes	Number of goats
Dedoplistskaro	235	10,000	79,453	1,545
Akhmeta	247	10,915	25,753	1,948
Telavi	220	7,190	18,617	1,907
Gurjaani	134	5,279	8,071	1,282
Sagarejo	190	31,079	*185,945*	12,635
Total Kakheti	**2,877**	**97,200**	**369,300**	**23,300**

TABLE 25

Population of pasture-users and livestock in Kakheti

Municipality	Target sample size	
	Low (90% confidence)	High (99% confidence)
Dedoplistskaro	246	276
Akhmeta	53	53
Gurjaani	20	20
Sagarejo	20	20
Telavi	11	11
Total	***350***	***380***

Survey respondents were required to be members of a household which practiced pastoralism, sampled from the municipalities outlined above. These are regions that are known to have a high number of livestock that use grazing land. Since no controlled random sample could be determined in advance (i.e. from a register of households or livestock owners), convenience sampling was used. Some minor sampling bias may therefore exist. To overcome this, interviewers approached respondents as randomly as possible without targeting specific sub-groups.

Survey design

The survey comprised of 80 questions using multiple choice or short form open numeric responses. The questions for the household survey were designed for the purpose of allowing for Net Present Value (NPV) and household income analysis. A gap analysis was performed to establish which of the revenue and cost variables were already known from the literature, such as the cost of supplementary feed, household food budget and fuel.

FIGURE 33

The project team conduct a pre-test of the survey in the municipality of Dedoplistskaro

(Photo credit - E Stebbings)

TABLE 26

Results of the survey coverage for households throughout study region

	Location of survey	Household location
Ahkmeta	55	84
Dedoplistskaro	247	153
Gurjaani	20	11
Sagarejo	21	80
Telavi	12	20
Other	-	7
Total	***355***	***355***

The questionnaire was pre-tested on 7 pastoralists in the municipality of Dedoplistskaro on the 6th and 7th of March 2018, with the assistance of GIZ local field office. The content, working and structure of the survey was modified according to the results of this pre-test. A stakeholder workshop and kick-off meeting for the project was held in Tbilisi on Friday 9th March 2018. The stakeholder workshop was attended by around 40 individuals, including representatives from the Ministry of Environmental Protection, Ministry of Economy, RECC, GIZ, Mercy Corps, IBiS, Ministry of Agriculture and the Shepherds Association. The workshop provided context for the project, helped provide data sources for analysis and informed the design of the household survey.

The household survey was implemented in April and May 2018. The survey responses were entered directly into SurveyXact software (www.survey-xact.de) using handheld electronic tablets, and three surveyors collected data from survey participants.

Survey coverage

The regional coverage of survey respondents is given in Table 26. The survey took place in the five regions as outlined in the study area (Figure 34), but also captured migrating pastoralists who lived in other regions. There were 355 complete responses in total.

Table 27 shows the percentage of livestock holding in the sample compared to the known number of livestock in the region of Kakheti. This is compared to the known statistics on pastoralist households in the area (Table 28). Overall, the survey sample represented 19% of known female sheep holdings for Kakheti, 6% of cattle ownership and 14% of goat ownership. The sample represents 12% of overall holdings in the region. The sample also contains a statistically significant representation of households residing in Dedoplistskaro, (with a margin of error of 4.7% relative to the total known population size), Sagarejo (margin of error 8.4%) and Akhmeta (margin of error 8.7%).

FIGURE 34

The project team conduct a pre-test of the survey in the municipality of Dedoplistskaro

(Photo credit - Luis Costa)

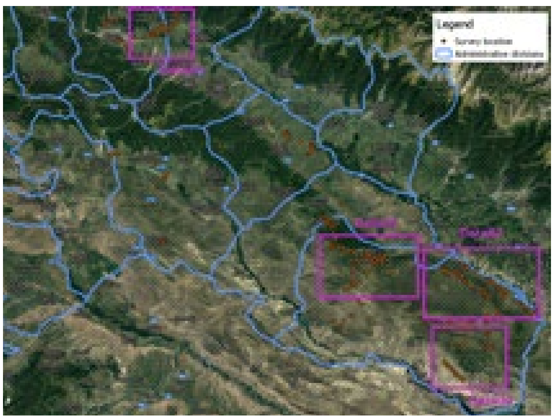


TABLE 27

Number of livestock owned by survey respondents and the region they live in

Sample household location	Lambs	Ewes	Goat	Calves	Cattle	Pig	Horse	Dog
Ahkmeta	10,006	2,345	603	388	1,146	126	291	242
Dedoplistskaro	7,436	8,970	583	795	1,500	339	61	277
Gurjaani	133	210	9	49	118	6	7	20
Sagarejo	24,813	35,259	1,337	1,026	2,808	10	240	438
Telavi	9,070	10,440	577	76	52	44	96	106
Kvareli	1,200	800	20	30	-	-	-	13
Sighnaghi	-	-	-	15	30	-	-	-
Tbilisi	-	-	-	35	60	-	-	6
Gardabani	600	1,300	20	-	-	-	2	10
Lagodekhi	1,000	1,000	-	-	50	-	4	12
Mtskheta	-	-	-	-	-	-	-	-
Total Kakheti	**54,258**	**70,324**	**3,149**	**2,414**	**5,764**	**525**	**701**	**1,124**

TABLE 28

Results of the survey coverage for sheep, goat and cow ownership

Municipality	Number sampled in survey				Percentage of population represented by sample			
	Hol-dings	Cattle	Ewes	Goats	Hol-dings	Cattle	Ewes	Goats
Dedoplistskaro	153	1,500	8,970	583	65%	15%	11%	38%
Akhmeta	84	1,146	12,345	603	34%	10%	48%	31%
Telavi	20	52	10,440	577	9%	1%	56%	30%
Gurjaani	11	118	210	9	8%	2%	3%	1%
Sagarejo	80	2,808	35,259	1,337	42%	9%	19%	11%
Other	7	140	3,100	40	0%	0%	6%	1%
Total Kakheti	**355**	**5,764**	**70,324**	**3,149**	**12%**	**6%**	**19%**	**14%**

Household demographics

The mean number of members in surveyed households is 4.7 people per household. The survey found that 39% of the sample were found to migrate their stock seasonally, whereas the remaining 61% remained at the pastures near their home all year round. 59% of the sample were found to depend on pastoral activities for more than half of their household income.

Segmentation by pasture-user profiles

Identifying groups of pastoralists with similar pasture-use profiles

The population of households that depend upon pastures in Kakheti vary widely in size, from households with one or two heads of livestock to large farm businesses with thousands of sheep. A set of pasture-user profiles were therefore required that characterise the uses of pastures at different intensities and dependencies for different types of household. For each pasture-user profile there will also be different quantities of livestock holding, in order to capture the different levels of profitability that may come from larger or smaller livestock holdings.

Cluster analysis is used to determine clusters of representative livestock holdings for each pasture-user, similar to the approach taken by Serneels et al. (2009) of Maasai pastoralist livelihoods. Clustering has been used in other similar studies for characterising pastoralist households (Thompson and Homewood 2002, Williams 1994). Segments are determined according to the size of livestock holdings (in sheep units) because it is anticipated that the size of holdings relate to the intensity of grazing pressure exerted by each household. These clusters are then used to establish separate population profiles.

Profile analysis

The survey observations were analysed for differences in mean for number of sheep units by their seasonal migration status and reliance on farming income. Welch's unequal variance two sample t-test with a 95% confidence interval was applied to determine whether these factors are significantly associated the size of livestock holding. There is a significant difference in mean number of sheep units for pastoralists that migrate and those that don't migrate. This led to a total of 8 profiles, 5 of which are migrators and 3 of which are residents.

Cluster analysis

Each segment was analysed using complete linkage hierarchical cluster analysis using Euclidean distances. The Euclidean dissimilarity measure was taken as 500 units. Where more than one cluster was identified using this hierarchical analysis, k-means analysis was used to determine the mean representative number of sheep, goats and cattle for that profile cluster.

Profile M: Seasonal migrator

This household use the pastures in lowland Kakheti during the winter months of October until March, then move their livestock to the

TABLE 29

Pasture-user profiles for migratory households

Profile	Sheep	Goats	Cattle	% households
M1	0	0	37	5%
M2 (small herd)	265	15	19	13%
M3 (medium herd)	574	27	0	12%
M4	825	25	38	6%
M5 (large herd)	1960	60	90	1%

TABLE 30

Pasture-user profiles for resident households

Profile	Sheep	Goats	Cattle	% households
R1	0	0	16	19%
R2 (resident)	122	17	16	42%
R3	3000	50	150	1%

summer pastures in the mountains. Table 29 shows the pasture-user profiles defined for migratory pasture-dependent households, and the size of these segments within the sample data. There are three clear clusters with sheep, goats and cattle, a fourth profile having sheep and goats only and a fifth profile owning only cattle.

Profile R: Resident (no seasonal migration)

Resident households do not move their livestock during the summer months and the majority live in the lowland of Kakheti all year round, with the exception of a few Tushetian pastoralists that use the summer pastures all year. There is one large robust cluster (R2) for this pasture-user profile with both sheep, goats and cattle, representing 42% of pasture users in Kakheti (Table 30). It is also common for residents to have cattle only (19% of pasture users).

Overall, it can be seen that residents have fewer sheep units relative to migrators, and amongst migrators and residents, there is a small percentage (1% of the overall population) that has a very large number of livestock. Amongst the residents, it is likely that these households are the 'farm businesses' that were identified during pre-testing of the survey.

TABLE 31

Stocking densities amongst pastoralists in Kakheti

Pasture-user profile	% households	Stocking density on leased land	Sheep	Goats	Cattle	Sheep units	Land under pasture lease (ha)
M1	5%	7.3	0	0	37	222	30
Small herd	13%	2.34	265	15	19	390	168
Medium herd	12%	2.5	574	27	0	601	240
M4	6%	2.12	825	25	38	1078	508
Large herd	1%	2.5	1960	60	90	2560	1024
R1	19%	7.3	0	0	16	96	13
Resident	42%	2.5	122	17	16	235	94
R3	1%	2.5	3000	50	150	3950	1580

Stocking density on leased land

For household that leased winter or village pasture, the stocking density per household is calculated by dividing the number of sheep units by the amount of pastureland that declared that they rented. The mean stocking density on leased land is 2.75 sheep units per hectare, or 2.24 sheep units per hectare for areas grazed by sheep only. Table 31 shows the breakdown and the average size of pasture leases by the different pasture user groups.

Appendix 4: Detailed income and NPV analysis of de-stocking by pasture user group

See next page

TABLE 32

Household budgets under de-stocking, with current level of lease-costs

SLM interventions	Migrator Small herd	Migrator Medium Herd	Migrator Large herd	Residents
BASELINE				
Sheep units	***390***	***1'071***	***2'542***	***230***
REVENUES				
Livestock sales	38'023	104'436	247'988	22'454
Wool	143	446	-	-
Cheese	5'582	8'754	-	5'601
Milk	1'391	-	-	2'883
Total revenue	**45'139**	**113'635**	**247'988**	**30'938**
COSTS				
Variable costs Vet	491	1'349	3'203	290
Supplementary feed	9'619	22'498	53'362	9'769
Salt	319	853	2'024	195
Cheese making cost	319	239	-	153
Labour Shepherds	8'624	13'296	28'826	5'380
Lambing	1'996	3'078	6'673	1'150
Milking	1'690	4'646		1'513
Total variable costs	**22'891**	**45'958**	**94'087**	**18'448**
GROSS INCOME	**22'248**	**67'677**	**153'900**	**12'491**
Gross income per sheep unit	*57*	*63*	*61*	*54*
Fixed costs Lease of pastures	9'316	28'262	56'910	5'147
Machinery	1'145	2'650	4'375	531
Family food	5'370	7'857	9'060	4'320
Firewood or fuel	481	481	481	623
Vehicle	1'989	1'989	1'989	-
Fixed household costs	**18'301**	**41'239**	**72'815**	**10'621**
Lease as a % total cost	***23%***	***32%***	***34%***	***18%***
Feed as % total cost	*23%*	*26%*	*32%*	*34%*
NET INCOME	**3'946**	**26'438**	**81'085**	**1'870**
Margin	*9%*	*23%*	*33%*	*6%*
Net income per sheep unit	*10*	*25*	*32*	*8*
DE-STOCKING INTERVENTION				
Sheep units reduced	*-190*	*-465*	*-1'322*	*-110*
New income per sheeps units	*10*	*25*	*32*	*8*
Forgone income	-10'839	-29'369	-80'028	-5'996
Avoided forage cost	3'094	7'155	14'378	3'979
NET INCOME AFTER DESTOCKING	**-3'799**	**4'224**	**15'436**	**146**
Net income per sheep unit	-10	4	6	-1

TABLE 33

Household budgets under de-stocking, with current level of lease-costs

SLM interventions	Migrator Small herd	Migrator Medium Herd	Migrator Large herd	Residents
BASELINE				
Sheep units	***390***	***1'071***	***2'542***	***230***
Current stocking/ha	*2.3*	*2.1*	*2.5*	*2.5*
REVENUES				
Livestock sales	38'023	104'436	247'988	22'454
Wool	143	446	-	-
Cheese	5'582	8'754	-	5'601
Milk	1'391	-	-	2'883
Total revenue	**45'139**	**113'635**	**247'988**	**30'938**
COSTS				
Variable costs Vet	491	1'349	3'203	290
Supplementary feed	9'619	22'498	53'362	9'769
Salt	319	853	2'024	195
Cheese making cost	319	239	-	153
Labour Shepherds	8'624	13'296	28'826	5'380
Lambing	1'996	3'078	6'673	1'150
Milking	1'690	4'646		1'513
Total variable costs	**22'891**	**45'958**	**94'087**	**18'448**
GROSS INCOME	**22'248**	**67'677**	**153'900**	**12'491**
Gross income per sheep unit	*57*	*63*	*61*	*54*
Fixed costs Lease of pastures	-	-	-	-
Machinery	1'145	2'650	4'375	531
Family food	5'370	7'857	9'060	4'320
Firewood or fuel	481	481	481	623
Vehicle	1'989	1'989	1'989	-
Fixed household costs	**8'985**	**12'977**	**15'905**	**5'474**
Lease as a % total cost	***0%***	***0%***	***0%***	***0%***
Feed as % total cost	*30%*	*38%*	*49%*	*41%*
NET INCOME BEFORE DESTOCKING	**13'263**	**54'700**	**13'995**	**7'017**
Net income per sheep unit	*34*	*51*	*54*	*31*
DE-STOCKING INTERVENTION				
Sheep units reduced	*-190*	*-465*	*-1'322*	*-110*
New income per sheeps units	*200*	*606*	*1'220*	*120*
Forgone income	-10'839	-29'369	-80'028	-5'996
Avoided forage cost	3'094	7'155	14'378	3'979
NET INCOME AFTER DESTOCKING	**5'518**	**32'486**	**72'345**	**5'001**
Net income per sheep unit	*28*	54	59	42

Appendix 5: A model of pasture recovery under multi-paddock adaptive grazing

In the absence of field experiments in Kakheti of actual HPG, the assumptions laid-out in section equation A5.1 through A5.13 has been used to model and estimate how forage production is impacted by the use of paddock systems on winter and village pastures in Dedoplistskaro. For the sake of illustration, we do this with reference to a small pasture user that has a 390 large herd size and 166 hectares of grazing unit under his management. The same set of equations apply to any pastoralist in Kakheti that has a unit of grazing land under his management. Equation A5.1 to A5.8 through equation are used to estimate the gain in forage productivity in spring time (March-May), in a typical year when there are no abnormal weather patterns.

Firstly, we start by understanding, how many of paddocks are required to allow for 30 days of recovery following 3 days of grazing (using equation A3.1).

Equation 18:	**#paddocks** = recovery period/grazing period + 1 = 30/3 + 1 = 11

10 paddocks will be run-through/grazed in a month of 30 days, using equation A3.2

Equation 19:	**#paddocks grazedt** = 30 days of grazing/days of grazing per paddock = 30/3 days = 10 paddocks

The average paddock size and paddock stocking density is given by:

Equation 20:	**Paddock size** = grazing unit / #paddocks = 166 ha/11 = 15 ha

The consumption of DM biomass in any one month is given by:

Equation 21:	**Consumption of biomasst** = SU x consumption/SU/day x 30 days = 390 SU x 1.5 kg/SU 30 days = 17550 kg DM

The total amount of DM biomass that is consumed in springtime (March to end May):

Equation 22:	**Consumption of biomass** = biomass grazed per month x months of grazing = 17550 kg x 3 months = 52650 kg

The amount of biomass that will recover is the same. Given a 30-day recovery period for anything grazed, the recovery stretches for 4 months, i.e. from the 1st of March until end of June, 30 days after the last paddock was grazed

Equation 23:	**Average biomass recovery per month**$_{\text{March-May}}$ = 52650 kg/4 months = 13162 kg/month
Equation 24:	**Recovery of biomass per ha per month** = 13162 kg/166 ha = 79 kg/ha/month

Supply of edible dry matter over the whole grazing unit k is given by:

Equation 25:	**Supply of DMk**= DM/ha x PUF x grazing unit = 600 kg/ha x 0.4 x 166 = 100’800 kg DM

For the purpose of adjusting the recovery period according to grazing intensity, we estimate grazing intensity within any one-month t, for any one paddock as follows:

Equation 26: $$\textbf{Grazing intensity} = \sum_{k=1}^{K} \frac{\text{Demand for edible DM}_k}{\text{Supply of edible DM}_k}$$

Where grazing intensity in spring (17550 kg DM/100800 kg DM) and autumn (17550 kg DM/50400 kg DM) is given by respectively 18% and 73%. Since grazing intensity is heavy in autumn, it is likely to take 60 days as opposed to 45 days for the forage to recover. It is assumed that there is no recovery of forage during those months when there is "free-play" in the non-growing season.

Equations 27 to 30 are used to estimate the gain in forage productivity in the second half of the year:

The total amount of biomass that is grazed in a paddock system over autumn is:

Equation 27: **Biomass consumed autumn** = biomass consumed per month x months of grazing = 17550 kg x 2 months = 35'100 kg

Given a 60-day recovery period for anything grazed, the full recovery period stretches for 4 months. However, since we assume that pastoralists use a paddock system in October and November (before "free play") the average paddock k will only get 30 days of rest, as shown in equation X.

Equation 28: =30 days

Assuming that the first paddock is grazed for 3 days starting end of September, after which it rests for 60 days, the second paddocks has animals entering first day of October and receives 57 days of rest (60-3) etc. The recovery rate for the forage that has been consumed over October and November will therefore be 50% of the full recovery rate, assuming that forage growth follows a sigmoid curve (Saul and Chapman 2002, Sollenberger et al. 2012). The average additional forage generated in October and November is therefore given by:

Equation 29: **Average biomass recovery per month**$_{\text{Oct to Nov}}$ = 17500 kg/month x 0.5 = 8775 kg/month

Equation 30: **Recovery of biomass per ha per month**$_{\text{Oct to Nov}}$ = 8750 kg/166 ha = 53 kg/ha/month

This set of equations have been used to give an indication of how forage production may be enhanced for a migratory pasture user, when paddocks are used to recover forage under the assumptions laid out above.

TABLE 34

Biomass per hectare (kg DM/ha) per month under the BAU scenario, the multipaddock scenario, and the additional biomass under the multipaddock system.

Month	BAU	Multi-paddock	Additional biomass	Month	BAU	Multi-paddock	Additional biomass
January	155	155	0	July	496	496	0
February	226	226	0	August	301	301	0
March	392	471	79	September	305	305	0
April	888	967	79	October	213	266	53
May	980	1059	79	November	169	222	53
June	618	697	79	December	130	130	0
Jan. - June	**3259**	**3576**	**317**	**July - Dec.**	**1615**	**1721**	**106**

TABLE 35

Assumptions and impacts of multi-paddock adaptive grazing for a small migratory pasture user

Assumptions – small migratory pastoralist	Spring	Autumn
Number of paddocks	11	21
Average paddock size (ha)	15	8
Number of paddocks grazed per month	10	10
Number of paddocks not grazed per month	1	11
Grazing intensity	Spring	Autumn
Supply of biomass per month (in kg DM)	100’800	50’400
Consumption/demand of biomass per month (in kg DM)	17’550	17’550
Grazing intensity	18%	74%
Biomass recovered per month (in kg DM)	13163	8775
Biomass recovered per month per ha (in kg DM)	79	53
Total biomass (in kg DM)	3576	1721
Outcome/results over 12 months	Multiple paddock	Baseline
Total biomass (in kg DM)	5297	4874
Additional biomass per ha (in kg DM)	423	
Additional biomass in DM in %	9%	
Avoided supplementary forage cost (in kg DM)	89 GEL/ha	

Over a year, the additional forage generated for pastoralist with small herd size is in the order of 423 kg of DM per ha or 129’430 kg for the whole 166 ha grazing unit, corresponding to a 9% increase in productivity (Table 35). Since all migrating pasture users purchase significant quantities of supplementary feed, the benefit may be valued in terms of the avoided costs associated with the purchase of hay. Selling at 0.21 GEL/kg hay (according to ELD household survey), the avoided supplementary forage costs are in the order of GEL 89 per hectare (equation 30).

Figure 35 shows the total available biomass under the baseline (continuous grazing) and that of multi-paddock system for a resident and migratory pasture user over an average year.

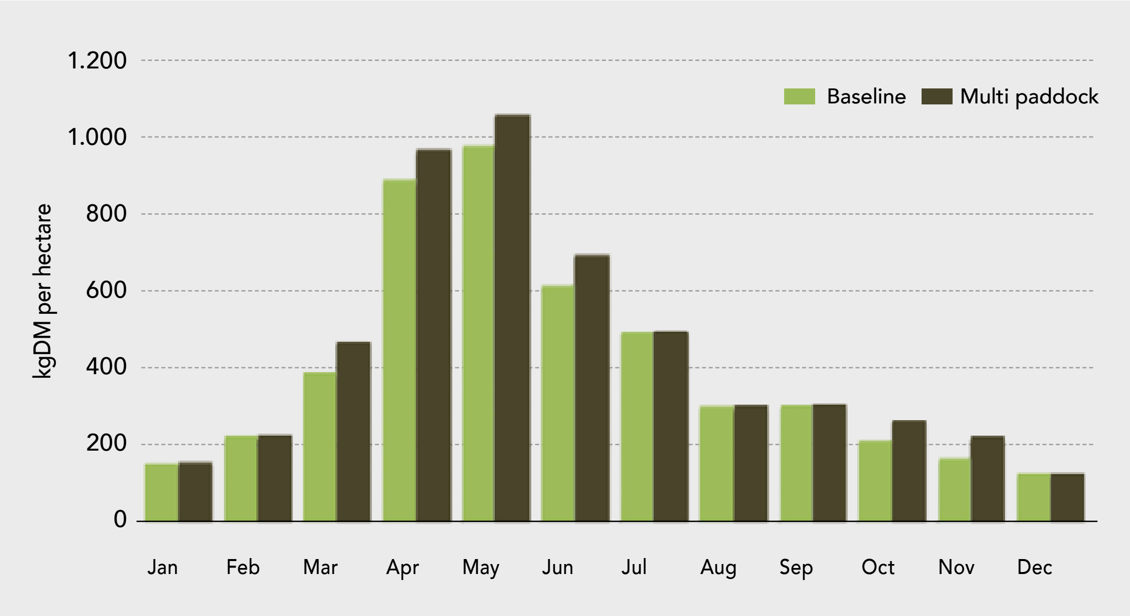
The case of a resident pasture user

In the case of village residents that uses pastureland for grazing all year round, it may also be of interest to optimize forage recovery by using a paddock system throughout the growing season. We assume that stocking densities on communal lands are 2.5 sheep per ha, e.g. 575 sheep units, on 230 ha of land (Table 11, main report).

Equation 30:	Avoided supplementary forage costs = 423 kg DM/ha x 0.21 GEL/kg = 89 GEL/ha

FIGURE 35

Example, biomass in the baseline and under a multi-paddock system for a migrating pastoralist



With 30 day recovery period, they should move animals within 11 paddocks from March to June, staying 3 days in each paddock (to avoid overgrazing according to the Savory Institute (2018). Presuming forage growth and weather patterns resemble those of 2016, during the month of July, it is of interest for villagers to double the paddock number to accommodate for the slowdown in growth of forage.

We also assume that the forage recovery period is 30 days from March to June. The recovery stretches into July (i.e. 5 months), until 30 days after the last paddock was grazed in June. The average monthly forage consumption and forage recovery is therefore given by equation 31 to 34.

Equation 31:	Paddock size = grazing unit / #paddocks = 166 ha/11 = 15 ha
Equation 32:	Average monthly forage consumption = 1.5 kg/SU x 575 sheep x 30 days = 25’875 kg/month
Equation 33:	Average biomass recovery per month = (forage consumption$_{March\text{-}June}$) / 5 months = 20700 kg/month
Equation 34:	Average biomass recovery per month per ha = 20700 kg/230 ha = 90 kg/ha

From July to November, under heavy stocking, the recovery period is 60 days. Any one month therefore only serves to recover half of the biomass consumed. Moreover, as we assume that pastoralists let their animal roam freely within their own pasture management unit as of December, the recovery is halted at this stage. The monthly recovery rate of forage in the second semester is therefore given by equation 35.

Equation 35:	**Average biomass recovery per month**$_{\text{Oct to Nov}}$ = 25’875 kg/month x 0.5 = 12’938 kg/month

TABLE 36

Assumptions and impacts of multi-paddock adaptive grazing for a resident pasture user

Assumptions - Resident pasture user	March-June	July-Dec
Number of paddocks	11	21
Number of paddocks grazed per month (30 days)	10	10
Number of paddocks not grazed per month	1	11
Average paddock size (ha)	21	11
Results, resident pasture user	March-June	July-Dec
Biomass consumed per 30 day month (in kg DM)	25’875	25’875
Biomass consumed Jan-June & July-December (in kg DM)	103’500	129’375
Biomass recovered per month (in kg DM)	20’700	12’938
Results, Resident pasture user	Multiple paddock	Baseline
Biomass per ha, first year (in kg DM)	5831	5043
Additional biomass per ha over one year (in kg DM)	788	
Additional biomass total over 230 ha (in kg DM)	181’125	
Additional biomass in %	16%	
Net-benefit of additional edible biomass	**GEL 38'036**	
Net-benefit of additional edible biomass/ha managed	**GEL 165**	

Appendix 6: Biomass and cashflow data underlying the valuation of annual rotational grazing

TABLE 37

Total dry-matter offtake under annual rotational grazing and NPV calculations (5 years)

Dry matter	Autumn		Year 1	Year 2	Year 3	Year 4	Year 5	
Rotational grazing - 41.5 ha protected, 124.5 ha grazed	Artemisia lerchiana + Bothri-ochloa ischaemum	Grazed in year t & protected in t-1	NA	60'453	60'453	60'453	60'453	
		Grazed in year t and t-1	11'9445	79'630	79'630	79'630	79'630	
		Available biomass	**11'9445**	**140'083**	**140'083**	**140'083**	**140'083**	
	Artemisia lerchiana + Salsola ericoidis	Grazed in year t & protected in t-1	NA	137'809	137'809	137'809	137'809	
		Grazed in year t and t-1	22'3353	148'902	148'902	148'902	148'902	
		Available biomass	**22'3353**	**286'711**	**286'711**	**286'711**	**286'711**	
	Artemisia lerchianae	Grazed in year t & protected in t-1	NA	59'665	59'665	59'665	59'665	
		Grazed in year t and t-1	59'075	39'384	39'384	39'384	39'384	
		Available biomass	**59'075**	**99'048**	**99'048**	**99'048**	**99'048**	
			Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	
Continous grazing - 166 ha pasture unit	Artemisia lerchiana + Bothriochloa ischaemum		159'260	159'260	159'260	159'260	159'260	
	Artemisia lerchiana + Salsola ericoidis		297'804	297'804	297'804	297'804	297'804	
	Artemisia lerchianae		78'767	78'767	78'767	78'767	78'767	
			Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	
Difference in Dry Matter offtake %	Artemisia lerchiana + Bothriochloa ischaemum		-25%	-12%	-12%	-12%	-12%	
	Artemisia lerchiana + Salsola ericoidis		-25%	-4%	-4%	-4%	-4%	
	Artemisia lerchianae		-25%	26%	26%	26%	26%	
			PV year 1	**PV year 2**	**PV year 3**	**PV year 4**	**PV year 5**	**NPV/ha**
NPV/ha moving from continuous to rotational grazing	Artemisia lerchiana + Bothriochloa ischaemum		-20	-10	-10	-10	-10	-GEL 59
	Artemisia lerchiana + Salsola ericoidis		-38	-6	-6	-6	-6	-GEL 56
	Artemisia lerchianae		-10	10	10	10	10	GEL 26

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