Assessing impacts of different grassland systems on land degradation and conservation in Faizabad (Tajikistan)

Master's Thesis

Submitted to the Faculty of Natural Sciences
University of Bern

by Christian Wirz
2009

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Cover photo: Seminomadic herder with his herd on the land of forest administration, Faizabad
(Christian Wirz, summer 2008)

Assessing impacts of different grassland systems on land degradation and conservation in Faizabad (Tajikistan)

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Preface

On my search for a topic I discovered an announcement for a master's thesis on pasture use in Central Asia. Besides being an area I was keen to discover and an incentive to acquire basic knowledge in Russian, I was convinced that a contribution to sustainable grassland management is necessary, since millions of people worldwide live from animal husbandry. Especially work experience on a Swiss farm and my bachelor thesis dealing with field workers in Spanish citriculture has strengthened my conviction that agricultural populations should be able to live from their activity. This led to my engagement in Central Asia, where both the problem of soil and vegetation degradation and the possible solutions of conservation measures are assessed. It is important to maintain the quality of more than 3.5 million hectares of grazing and haymaking areas in Tajikistan (Akhmadov et al. 2006) on a long term.

This master's study is a continuation of the PhD study of Bettina Wolfgramm and the Diploma thesis of Erik Bühlmann both dealing with natural resources in Western Tajikistan. The Work Package *"Natural Resources in Sustainable Development"* (WP4) of the Centre for Development and Environment (CDE) and the National Centre of Competence in Research (NCCR) North-South build the institutional and financial framework of this thesis.

This master's thesis could only be achieved thanks to the priceless support of various people who cannot all be mentioned. Special thanks go to the tutors of this thesis Bettina Wolfgramm, Hanspeter Liniger and Hans Hurni, and to Gulniso Nekushoeva for their valuable inputs, to the local partners Roziya Alieva and the team of the Central Asian Mountain Partnership (CAMP) for their support (infrastructure, apartment, visa…), to the English language editor Ann Greco, to Abdusami Dshahonow for his excellent translation and organisational support, to Patrick Kuss and Abdullo Madaminov for their technical support in botanics, to all interview partners and field assistants and, last but not least, to my family and my partner for their moral support.

Abstract

This master's thesis was carried out within the framework of the National Centre of Competence in Research (NCCR) North-South. It is a continuation of the erosion-modelling performed by Bühlmann (2006) and the land cover type mapping by Wolfgramm (2007) in the same area. The main task of this study is to deepen knowledge on Sustainable Land Management (SLM) for grassland, because in the assessed area detailed knowledge is only available for cropland. The overall goal is to contribute to the understanding of the impact of different grassland management systems on land degradation and conservation processes. Therefore specific objectives are formulated:

1) A spatial delimitation of existing Land Use Systems (LUS) for grassland, based on management.

2) A spatial analysis of selected conservation measures and degradation indicators.

3) An aggregation of impacts of conservation and degradation on Ecosystem Services (ESS) for each LUS.

4) A comparative assessment of 4 case studies of grassland management.

The methodology was strongly based on field work in a 10 by 10 km^2 study area of Faizabad, Tajikistan, from June to September 2008. After mapping a part of the study area based on Land Use Systems (LUS) of different management, a field-protocol for ten sampling sites per LUS was filled in. It included a plant-ecological part and standardised indicators provided by WOCAT (Liniger et al. 2008A). WOCAT stands for World Overview of Conservation Approaches and Technologies and is designed to collect knowledge on practices of land management. In a further step, the questionnaires of WOCAT on conservation technologies (idem: 2008A), conservation approaches (Liniger et al. 2008B) and mapping (idem: 2008C) were filled in together with local experts. Therefore case studies of management were selected where different measures of grassland conservation were applied.

The methodological approach resulted in a LUS map, together with detailed information on the way these LUS are managed. It is possible to distinguish areas of strong degradation (hot spots) from quite stable and well-conserved areas (bright spots):

- The following hot spots of degradation could be identified:
    - Pasture areas used daily or regularly by the herds of the villages: all types of degradation processes – concerning vegetation, soils and water – reach the highest extent and degree in these areas. Especially trampling paths are subject to erosion by heavy rains and by wind. Vegetation is degraded in quality (palatability) and quantity (cover and biomass);
    - Former cropland used for the production of wheat and other crops during and after civil war in the second half of the 1990s: soils are still suffering from past tilling and from ongoing water-erosion. Vegetation has recovered in terms of biomass but is dominated by species with a low palatability;

- There are further areas that are prone to degradation, but where degradation is less present because of selective use and inaccessibility:
    - Marginal areas next to streams: they are affected by water degradation processes, especially gully erosion. Vegetation is abundant in quantity but by a high proportion of either thorny shrubs or other non-palatable species they are not very interesting for use;
    - Resting places in flatter areas: they are typically located on plateaus next to rivers and stand out by rather high cover values and short vegetation that is intensively grazed during regular short time-periods. Besides the degradation of biomass these areas suffer from compaction and reduced plant diversity.
    - Seminomadic areas with a considerable distance to villages: they are mostly dominated by non-graminoids, but still interesting for pasture use because of many (medical) plants considered as healthy for the animals. Erosion becomes a problem when vegetation is overused, for example when stabilising trees are cut down.

- Cut and carry areas show less signs of degradation and may be considered as bright spots of conservation:
    - Haymaking areas are little degraded areas, even if tree cover is quite low. Because of possible double use for fodder-production and grazing they are interesting in productive terms. But even if animals bring dung, fertility has been declining recently.
    - Fruit and haymaking areas: besides problems with droughts, be it compaction or less irrigation water, these areas are the ideal LUS in terms of SLM. But it is by a high labour input that returns in terms of fruits and fodder are generated. This means that the main (future) challenge is maintaining these areas.

Together with four case studies about specific management measures it is possible to conclude that there are a series of criteria influencing the decision to implement SLM and success-factors for such measures. It can be said that conservation measures that do not cost much or require qualified labour and at the same time assure production are likely to be implemented by land users. However, these measures are not necessarily efficient in terms of SLM, as can be seen for the rotational grazing systems of villages. High-input measures such as orchards are spreading more and more. But besides financiation, implementation often requires good relations to administration or a facilitator such as the former director of Soil Institute, Tajikistan, who helped land users acquire land for orchard establishment.

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Abbreviations

AKF	Aga Khan Foundation
CAMP	Central Asian Mountain Partnership
CDE	Centre for Development and Environment
DPSIR Framework	Driver -Pressure- State- Impact- Response Framework
ESS	Ecosystem Service(s)
FAO	Food and Agriculture Organisation
LADA	Land Degradation Assessment in Drylands
LUS	Land Use System
NCCR	National Centre of Competence in Research
OSAVI	Optimised Soil Adjusted Vegetation Index
SOC	Soil Organic Carbon
SLM	Sustainable Land Management
WOCAT	World Overview of Conservation Approaches and Technologies

1 Introduction

After a short overview of the problems addressed and a description of the study area, the objectives and research questions are presented.

1.1 Problem definition

The problem tackled has a dimension with respect to content (see the first two points below) and to methodology (third point):

1) Since the breakdown of Soviet Union, Tajikistan, as the poorest of the new Central Asian Republics, is reported to face severe problems with Soil and Water Conservation and especially with overgrazing (Aga Khan Foundation Tajikistan AKF 2007). This is clearly a problem for a population that mainly depends on agricultural activities and requires solutions in terms of Sustainable Land Management (SLM).
2) Grazing land has intensively been studied by Soviet scientists and geobotanical maps exist for the whole of the former USSR. However, such studies are not up-to-date. They are further adapted to large state farms more than to local peasants (high academic level) and the scale of the available maps is rough: the geobotanical map of Tajikistan distinguishes between two vegetation formations in the study area (Atlas of natural resources of Tajik SSR 1985). Especially data about grassland quality is missing: Bühlmann (2006) only provides the two categories of *"intensive"* and *"extensive grazing land"*. Wolfgramm (2007) provides a raster data classification for Faizabad including 22 sub-classes. But neither is specific information on grassland contained. Spatially aggregated, general knowledge about grassland management measures and their impacts on degradation and conservation of grasslands is needed.
3) The World Overview of Conservation Approaches and Technologies (WOCAT) is an international method developed for assessment of conservation and degradation by Food and Agriculture Organisation (FAO) and CDE. WOCAT assessments have proven to be efficient in many parts of the world. Only few case studies exist for grazing lands (Liniger and Critchley 2007). The same is true for mapping experiences with WOCAT methodology and explains why grazing land is focussed. During a field study in summer 2008, standardised WOCAT questionnaires and indicators, complemented by vegetative indicators, will be applied to different Land Use Systems (LUS) identified on grassland.

1.2 Study area

The availability of Quickbird (high-resolution) satellite imagery for Faizabad and of the mentioned studies logically leads to the choice of this study area for a WOCAT grassland assessment. This choice is supported by Landsat ETM+- based land cover classification (Wolfgramm 2007) of Faizabad, which is useful in providing possible classification criteria for field classification.

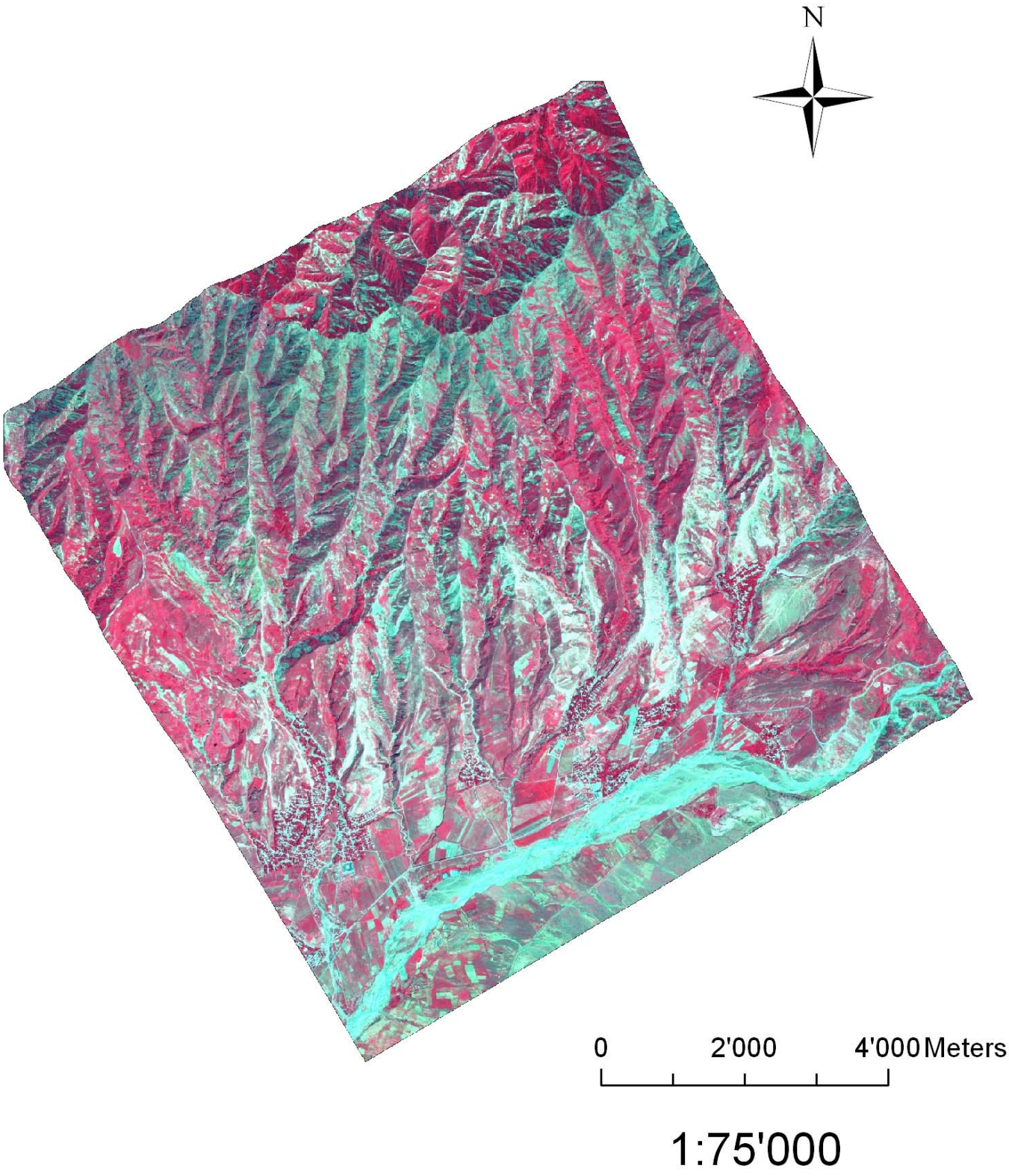

Figure 1: Quickbird scene of the study area in Faizabad.

The Quickbird satellite image represented in figure 1 was shot in June 2006 and is used in this study for LUS classification of the study area. A Digital Elevation Model also used by Bühlmann (2006) highlights that the study area mainly consists of North-South oriented ridges. The mapped area within the study area will be called assessment area.

From the four bands of the Quickbird image one is sensitive in the range of blue colours, a second one covers the green range and the remaining bands are vegetation indicators: the red channel (band 3) and the near infrared channel (band 4). Bluish colours on the satellite image indicate areas with low cover, whereas red colours stand for high cover.

Faizabad is around 50 km to the west of the capital Dushanbe. The grasslands assessed range from an altitude of 1300 to 2100 m, with an average annual rainfall of around 900 mm according to data from the Tajik Meteorological Service (see Wolfgramm 2007: 110). A local expert mentions even lower figures: on the average 600-650 mm, in 2007 and 2008 (till September) even only 200 mm. The hill slopes studied have slope values ranging from moderate to very steep (according the categories of Liniger et al. 2008A: QT 32) and are dominated by brown soils from loess deposition.

A dozen villages lead their animals to the pastures of the study area and have their haymaking areas there. This is why the focus of the interviews is on these villages, especially on Karsang, where all the experts of the case studies come from.

1.3 Objectives and research questions

The overall goal is to contribute to the understanding of the impact of different grassland management systems on land degradation and conservation processes.

More specifically, four objectives with corresponding research questions define the study's leitmotif:

1) A spatial delimitation of existing Land Use Systems (LUS) for grassland, based on management.
    - By which criteria can a LUS on grassland best be visually and spatially delimited?

2) A spatial analysis of selected conservation measures and degradation indicators.
    - How do values for the different indicators change depending on the LUS?

3) An aggregation of impacts of conservation and degradation on Ecosystem Services (ESS) for each Land Use System.
    - Which are the impacts of different LUS on selected ecosystem services?

4) A comparative assessment of 4 case studies of grassland management.
    - Which conservation measures are interesting in ecological as well as in productive and economic terms?

2 Theoretical background

The presentation of sustainable land management and the approach used for land use mapping is followed by the explanation of the systemic concept behind field work.

2.1 State of the Art

Principally, two approaches to resource degradation and conservation topics exist:

- First, a socio-economic perspective, in order to understand the relation of people to their resources. For instance, land access problems are discussed as examples of the tragedy of the commons (see Hardin 1968). Investigations in Kyrgyzstan show how important it is that land users faced with situations of overgrazing recognise these as problems of resource management (Liechti 2008A). Only then will they be ready to change their management. Liechti and Biber-Klemm (2008) further show that questions of power over land arise, which require negotiation.
- Second, a biophysical view, if land degradation shall be quantified on the basis of biological, chemical and physical indicators. In the last years many studies using remote-sensing have been performed which aim at the use of raster data classification to assess land quality. Often a combination with field mapping gives a multi-level view on land (see Wolfgramm 2007 and Röder et al. 2008). A map as the outcome of classification gives information on the spatial distribution of degradation patterns. This is a prerequisite for decision-making. In a biophysical view, besides spatial assessment, the technical aspect of management is decisive (Liniger et al. 2008A).

This master's thesis focuses on the biophysical perspective. It also includes certain socio-economic aspects related to the observed degradation processes, especially livestock numbers as important drivers of degradation. In the following, Sustainable Land Management (SLM) as understood by WOCAT is described. Once the notions of degradation and conservation are understood, it is necessary to talk about the way of assessing them: SLM is thus transformed to a Land Use Systems (LUS) Mapping Approach.

2.1.1 Sustainable Land Management

The Broensted report introduced Sustainability as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (*World Commission on Environment and Development 1987: 43). SLM further includes the dimension of resource management. WOCAT methodology especially convinces in this question by assessing both land resources' degradation and conservation, which are essential for rural populations such as in Faizabad:

> *"the majority of people in developing countries are directly dependent on land resource. Maintaining or improving the quality of these resources is thus an important step towards improvement of rural livelihood and poverty alleviation, and finally, towards more sustainable development" (Liniger et al. 2008).*

1) Degradation:

In order to understand the necessity of conservation measures on grazing land, degradation has to be explained. WOCAT describes degradation as state indicators, making response (conservation) necessary. Different forms of degradation are distinguished, reaching from water, wind, chemical, physical to biological degradation processes. These processes are caused by two types of drivers:

- Direct drivers: they are often visually identifiable degradation or conservation factors. Among them, the most relevant factor for grazing lands is overgrazing (for an overview see figure 2 in chapter 2.2.1). It is generally assumed that overgrazing is visible as (a consequence of) too many animals on a surface unity. A study in Western Tajikistan proposes stocking rates as a possibility to assess overgrazing (AKF 2007). Röder et al. (2008) point out the necessity of small-scale assessments to observe this effect. On a higher scale the effects of stocking rates might be overlapped by the effect of landscape diversity. The chosen study design for Faizabad considers LUS as the basic aggregation units. It thus takes into account the necessity of high spatial resolution.
- Indirect drivers: these are mechanisms reinforcing the pressure (direct drivers) on grazing lands. In this context, land access and especially the land reforms of the 1990s are important factors. In 1993 and 1995 two presidential decrees assigned a part of former collective land to farmers. They were to be able to rent land on the long term from then on by founding farmers' associations (dekhan farms). In reality, the government failed in distributing land equally and villagers with more financial resources and good relations to land administration were favoured compared with poorer families and those with women as household leaders (Gomart 2003). It is important to note that in many cases communal land surrounds the villages in the valley floors. Management strategies are difficult to apply because of free-riding:

  "In most places grazing land can be considered as a typical "open access resource" with its associated problems. Each household from the village or from a hamlet has the right to graze animals. As each household seeks to achieve its household goals, a common strategy applied by all households is to maximize herd sizes. Thus, overstocking is a common phenomenon. [...] Individual farmers fear that if they further decrease their herd size but not all other farmers do the same, others might profit and increase their herds" (Ludi 2002: 68).

WOCAT field assessments and mapping questionnaires address direct reasons such as overgrazing (visible as trampling) and indirect reasons of degradation like (invisible) poverty (Liniger et al. 2008C; Grob and Gasser 2008). They also look at the quantification of degradation impacts on productive and self-sustaining functions of land, called Ecosystem Services (see chapter 2.2.2).

2) Conservation:

WOCAT defines land conservation as a set of response indicators chosen to tackle land degradation. These conservation measures are conservation technologies, the most of which are mainly designed for cropland management. Only the group of conservation technologies denominated *"grazing land management"* (Liniger et al. 2008C: E15) is grassland-specific. In this case management is understood as the control of grazing pressure. Grazing land management can be described as *"the art and science of planning and directing development, maintenance, and use of grazing lands to obtain optimum, sustained returns based on the objectives of land ownership"* (Vallentine 1990: 1). What is needed are conservation measures on grazing land that are able to regulate frequency of grazing and guarantee the land's productivity on a long term.

3) Assessing grazing land quality:

Classification of grazing land has often been performed either under an exclusive consideration of land cover and biomass production (for example Okello 1996 and Kinyua 1996, both in Kenya) and / or for more distinct geographical and climatic conditions than Central Asia, such as in Utah (Vallentine 1990). In this study, biomass production is undocumented except for the indicator *"Biomass reduction"* (see chapter 3.4.1) due to the criteria of simple applicability by land users. But palatability factors are included as they are an important measure of pasture quality. Vallentine (idem) describes palatability as a set of factors, by which a plant makes itself attractive or not for herbivores. In table 1 some factors determining palatability are shown.

Increased palatability	**Decreased palatability**
Plant physical factors (physical or morphological factors):	
High succulence	High percent dry matter
High leaf : stem ratio	Low leaf : stem ratio
Leaves fine, tender	Leaves coarse, tough
Twigs small, spaced	Twigs large-diameter
High accessibility	Low accessibility
Not thorny or spiny	Thorny, spine barriers
Environmental factors:	
Plant surface moist and / or clean	Plant surface dry and / or dust covered
Plants normal	Plants damaged by insects / disease
Chemical factors:	
High proportion of crude proteins, sugars, fat, cellular contents	High proportion of fibre, lignin, silica; low proportion of magnesium, phosphorous
Low proportion of anti palatability metabolites, high digestibility	High proportion of secondary plant metabolites, low digestibility

Table 1: Palatability factors, on the base of Vallentine (1990).

These palatability factors help define possible indicators for grazing land quality, some of which will be discussed:

- Greenness of herbaceous layer: The greener vegetation is, the higher its fodder quality, as Vallentine (1990) could prove for pastures in Utah. At the same time green vegetation indicates the availability of moisture. Both greenness and moisture are criteria which can be identified by remote sensing procedures (tasselled cap transformation). But in the field they are difficult to measure.
- Perennial plants: Perennial plants indicate higher fodder quality than annual plants. However, it is not sure if perenniality will be easily recognisable in the field as plant rests might already be decomposed and as there are also thin perennial grasses. This is why information on the life-cycle of the assessed plants from experts is important to complete this indicator.
- Structural parameters include the layers of vegetation (tree, bush and herbaceous layer). The single layers can be further split up. This shall be done for the herbaceous layer, which will be split up into *"graminoids"* and *"non-graminoids"* (distinction used by Wolfgramm 2007). Graminoids are generally more palatable than non-graminoids.

- Vegetation height: Together with vegetation structure height is a further indicator of pasture-state. Overgrazed pastures contain very low blades of grass, undergrazed pastures tall and old grasses. Height is roughly assessed and completes the image of vegetation structure.
- Patch grazing: Ungrazed (due to dung and other factors) and overgrazed patches (due to very palatable species) on a small surface lead to losses of fodder and to the degradation of cover. The bigger ungrazed and overgrazed patches, the stronger is degradation (idem). Measuring this parameter is difficult and therefore not performed.
- Rooting depth (and density): this indicator is proposed by Wolfgramm (2007) and is important for retaining water in soils. However, as field work is taking place in the dry season and soil is thus assumed to be compacted, it might be difficult to dig in order to estimate rooting depth. This indicator is thus left apart.
- Leaves to stem ratio: This indicator is proposed by Vallentine (1990) and follows the principle of higher availability of leaves leading to enhanced palatability. This indicator is difficult to measure and there may be species where enrolled leaves (generally low palatability) lead to an artificially high palatability. This is why this indicator is hardly measurable.
- Thorny plants: defence and avoidance strategies as discussed in Gordon et al. (2008) are plant strategies to avoid herbivory. This negatively affects palatability. Some examples of such indicators are thorny plants, grasses with rolled leaves, or growth within other plants. In this study only thorny plants are further considered.

A study carried out in the Pamir Mountains gives an example of how grazing land quality classes could be measured in the given context of Faizabad AKF (2007). Some of the mentioned categories (see table 2) and indicators are used to define vegetation degradation indicators in the framework of WOCAT mapping together with the former list of palatability indicators.

Class	Description
1	Good pasture, with a high proportion of grasses or legumes. Inedible biomass no more than 40% and productivity of edible plants up to 2000kg/ha
2	Inedible proportion of biomass no more than 50%, Productivity of edible plants up to 1000 kg/ha.
3	Proportion of grasses and legumes reduced and in dryer areas there is a higher proportion of subshrubs such as *Artemisia*. Inedible biomass is likely to take up 50-70% of the total, and edible biomass between 400-600kg/ha.
4	More than 75% of the biomass is inedible, edible biomass makes up 150-500kg/ha. Physical soil erosion may be visible, particularly on slopes.
5	Non-edible species dominate and may include thistles and spiny bushes. Edible biomass about 150kg /ha and physical erosion widespread.

Table 2: Degradation classes, on the basis of Dushanbe Institute of Botany (AKF 2007).

2.1.2 Land Use System mapping approach

Here, information is given about the mapping units and the mapping concept. In order to define a LUS, land cover type (be it grasslands, croplands, bare soils or a combination of these factors) and landuse type (be it grazing, haymaking and in the case of grazing, to the density of grazing animals) are needed (see Liniger et al. 2008C: E3).

Wolfgramm (2007) combines terrain-specific indicators (slope, curvature) and reflectance (land cover) to in her land cover classification. The notion of land cover is used to describe fractional vegetation cover together with any other forms of soil cover, especially mulch. Besides cover and slope further criteria are introduced to define a LUS in the terrain (see chapter 3.2.1).

WOCAT calls attributes the biophysical, socio economic and land use related factors making up a LUS. Slope is an example of an attribute. Bühlmann (2006) mentions the risk of errors in slope estimations when using raster data to interpret slopes. This can mean over- or underprediction of erosion risk and helps explain why raster data classification needs to be complemented by field assessments such as proposed by WOCAT. This is why field assessments can help improve existing raster data classification algorithms for Faizabad (Wolfgramm 2007).

As far as the mapping approach is concerned the last years of research have seen a shift from pure vegetation mapping using ecosystems or biomes as borders of vegetation units (see Kent and Coker 1992 and Dierschke 1994) to a broader designed land cover mapping (Alexander and Millington 2000A). This type of mapping is suited to remote sensing applications in that it focuses on spectrally relevant indicators. Following this tendency, the chosen mapping approach combines visual LUS delimitation on a satellite image with soil and vegetation indicators partly proposed in the WOCAT mapping questionnaire (Liniger et al. 2008C).

2.2 A System's Approach

Two theoretical concepts help understand the context of the study. First, an understanding of human-impact dominated grassland system is needed. Then, the value of this system must be measured.

2.2.1 Theoretical framework

WOCAT adopts a System's approach based on the Driver -Pressure- State- Impact- Response Framework DPSIR (see figure 2). Driving forces and indirect reasons have already been explained. The state itself is an integral of different types of soil and water degradation. And impacts mean the influence of a given state on ecosystem services. If a resource is in a bad and deteriorating state, a reaction is necessary. It can and should be undertaken by different participants following the idea of a multi-stakeholder approach (for examples in the Pamir see Breu and Hurni 2003). These responses in turn retroact on the impacts and drivers.

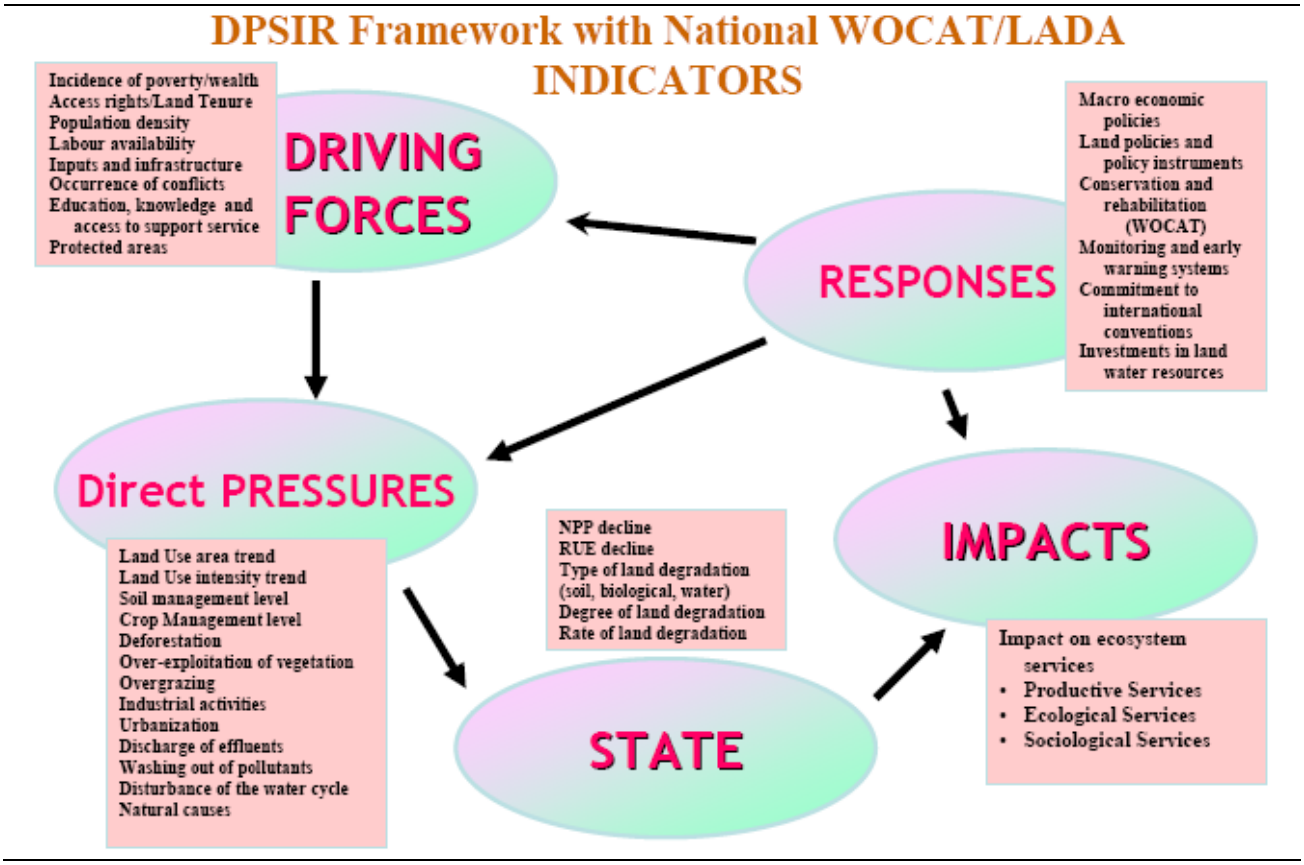

Figure 2: Components of a Degradation / Conservation System (Liniger et al. 2008C).

2.2.2 Ecosystem services

WOCAT (Liniger et al. 2008C: E 20) looks at ecosystem services to see whether the functions of the soil and water system desired by humans can be provided, given a certain LUS. They cannot be provided above a certain threshold of degradation. For Wolfgramm (2007), erosion has implications on the functionality of a soil, for example on fertility. Millennium Ecosystem Assessment (2005) mentions four types of ecosystem services (ESS) (provisioning, regulating, supporting and cultural), which WOCAT merges to three categories:

1) Productive services:

For grassland ecosystems fodder quality and quantity are important. Besides other indicators indicated in figure 3, the palatability of the present species is an important indicator of fodder quality. The proportion of palatable or edible species is a measure of pasture quality or degradation:

> *"[...] it is the proportion of grasses growing amongst the unpalatable species which indicate the quality for the pasture for grazing"*.[…] *"In terms of pasture quality edible biomass is more important than total biomasss"* (AKF 2007: 22-23).

2) Ecological services:

These are regulating and supporting functions. Many of these functions are implied in soil building. Figure 3 gives an overview of some of the most important functions of grassland, as far as soil quality is concerned (Rinehart 2008). Some of these crucial services chosen for assessment by the author are soil organic matter content, soil cover and structure and biodiversity.

Soil Building Characteristics of Grassland Ecosystems

Pastures help to increase organic matter and humus in the soil, which results in:

- Granulation of soil particles into water-stable aggregates
- Decreased crusting
- Improved internal drainage
- Better water infiltration
- Fixation of atmospheric nitrogen
- Release of bound nutrients
- Increased water and nutrient storage capacity

Source: Beetz, 2002

Figure 3: Grassland Ecosystem.

3) Socio-cultural services:

These are services relevant for human well-being such as conflicts arising through resource scarcity, net income generated from the land resources or food security provided by them.

This thesis only assesses productive and ecological ESS (see chapter 3.4.4) because the chosen assessment approach depends on field assessments which are not appropriate to address socio-cultural aspects.

3 Methodology

After explaining its overall framework the methods used in this study are explained in more detail: a workflow description is given and then the four methodical pillars are discussed.

3.1 Methodological framework

The clue of the applied methodology lies in combining quantitative data with perspectives of local experts. In figure 4 an overview of the three principal methods with their contributions to the initial objectives is given. These are quantitative methods based on plant-ecology and on the WOCAT-methodology on the one hand and interviews on the other hand.

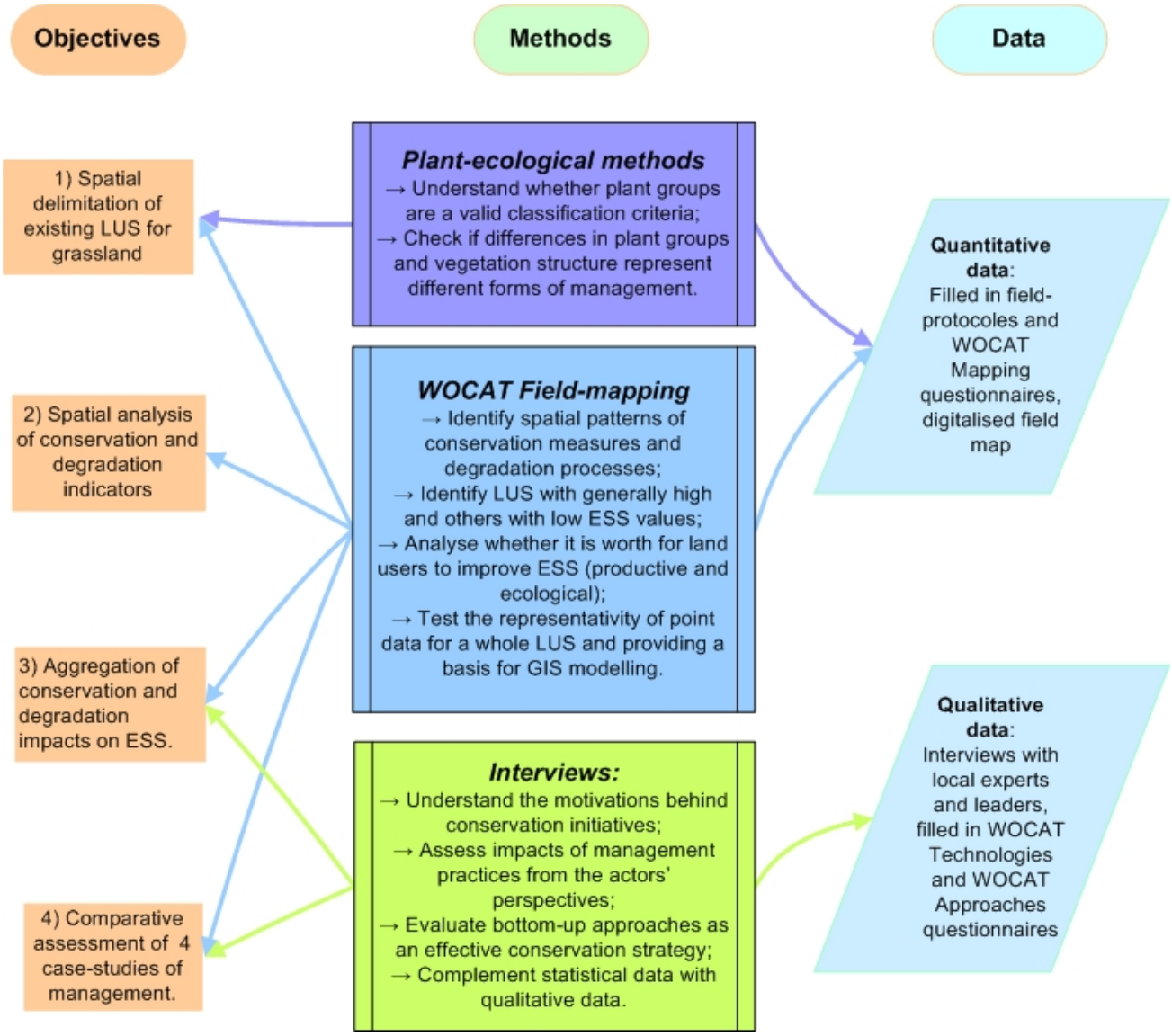

Figure 4: Three constituting methodological blocks.

3.2 Work steps

A series of steps is necessary to put land uses on paper, as seen in the following.

3.2.1 Visual classification of Land Use Systems

The basic unit of classification used in Faizabad is the LUS. For effective mapping a classification scheme is developed. Land users' information help to define criteria for LUS classification.

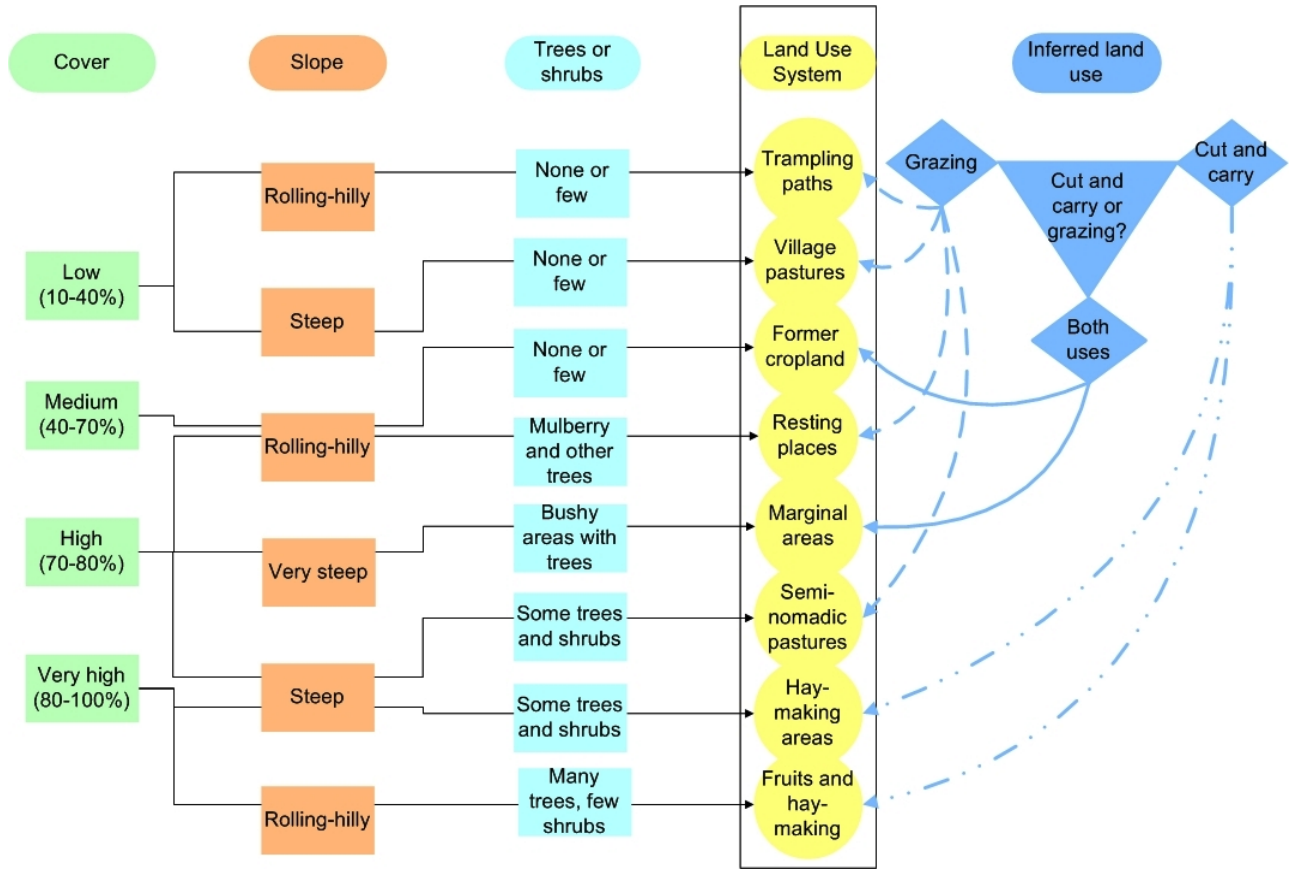

Figure 5: LUS classification tree with slope categories according to WOCAT (2008C).

As can be seen in figure 5, mainly two classification criteria are significant to define a LUS: cover and slope. It is important to note that the combination of cover and slope makes out the different LUS, because in some cases values for either slope or cover may differ from those indicated. The proportion of trees is in some cases an important criterion, too: typically, the LUS *"Marginal areas"* contains natural trees and shrubs, whereas *"Fruits and haymaking"* stands for fruit trees and in many *"Resting places"* there are mulberry trees (their leaves are used to feed silkworms) or other trees providing shadow. *"Inferred land use",* on the other side of the LUS in figure 5, is the effective land use in the area which is either assumed (for example by cut grass that indicates cut and carry use) or found out by asking land users. This step of assessing land use can be considered as a control of the cover and slope-based classification process.

The study area is mapped on the basis of the above explained LUS. Therefore, transects are laid in the main direction of the North-South ridges. In the morning, a first ridge is used to walk upwards: simultaneously the ridge itself and the visible side of the two neighbouring ridges are mapped visually and by the use of binoculars. In the afternoon the next but one ridge is descended in direction of the village, mapping again the present and the neighbouring ridges, as far as possible. The borders of LUS are directly depicted in a print of a Quickbird satellite image (scale: 1: 10'000). For unclear areas, for example because cover is between the categories high and medium, additional information by land users and village-leaders is searched for.

The colours of the satellite image give a general idea on cover (see chapter 1.2). It is also possible to generate cover values based on a satellite image by using its bands 3 and 4 to generate a vegetation index: the Optimised Soil Adjusted Vegetation Index (OSAVI). To generate the OSAVI the same calculation algorithm is used as developed by Bühlmann (2006: 23). The resulting values are plotted against the observed cover values in the field, for the 80 field sampling sites. The regression equation indicates a low negative exponential relation between the OSAVI values and the cover values estimated in the field (see figure 6). The R^2 factor of nearly 0.6 shows that the OSAVI index overall well represents effective field cover values.

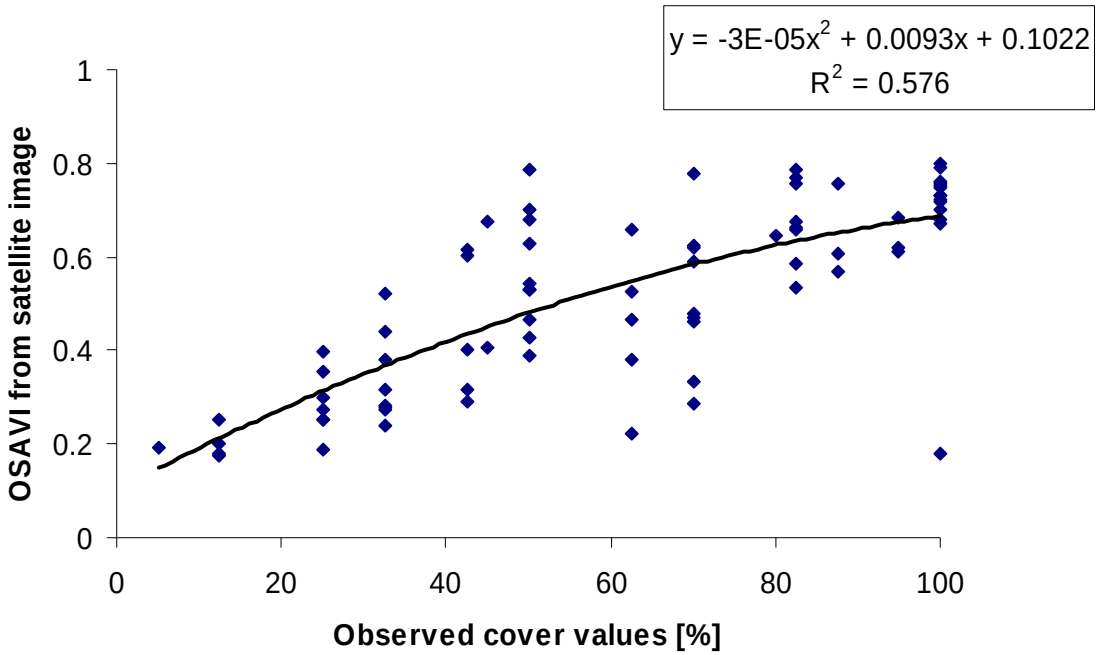

Figure 6: Quadratic regression between observed cover and OSAVI values for 80 sampling sites.

3.2.2 Sampling design

A stratified randomised sampling design is used to select ten sampling sites per LUS. The idea is to use 30 by 30 metre sampling sites, which reflect the size of a Landsat ETM+ pixel. Together with the use of sampling sites of Wolfgramm (2007) this makes the study comparable with the one of Wolfgramm, based on Landsat ETM+ imagery. The selection procedure is as follows:

- Once the study area is mapped, the sampling sites of Wolfgramm (idem) are assigned to the LUS visually. Up to ten of these points per LUS are revisited and reassessed. It is important to respect a certain spatial and altitudinal distance between the sampling sites. As the sufficient number of ten points per LUS is not found among Wolfgramm's point in every case, step two is applied:
- The missing points are defined in the polygons of the underrepresented LUS. The idea is to visit places that are not at the margins of the generally quite large LUS units (or polygons). They should further be distributed all over the study area. The randomised sampling site selection-procedure is explained in chapter 3.3.
- Once the points are defined, they are fed into a GPS so as to permit finding the points in the field. For each of the chosen 80 sampling sites a local assessment of field-indicators is performed. In a square of 30 by 30 metres around the sampling site's centre indicators of the WOCAT mappng questionnaire (Liniger et al. 2008 C) and additional, suitable indicators are assessed. These are partly identified together with local herders. Indicators referring to vegetation are based on the method of vegetation description (see Kent and Coker 1992, Dierschke 1994 or Tremp 2005). The indicators used will be described in chapter 3.3.

3.2.3 Aggregation per LUS

An important step of the current study is to merge the results of the single LUS sampling sites to general conclusions per LUS. This gives an impression of degradation and conservation patterns and their impacts for specific land management types. This step is performed together with local experts in order to validate the field observations and to identify whether the LUS are useful classification criteria for land users. These experts also help identify dynamics for the different LUS and provide other LUS-specific information. For this aggregation the standardised WOCAT mapping method is used (Liniger et al. 2008C).

To better understand different forms of land use, case studies for four different conservation measures in the area are carried out. Therefore, again interviews are necessary. The case studies must either represent spatially dominant patterns of use or, otherwise, be of importance for the livelihoods of local population. The WOCAT questionnaires on technologies (Liniger et al. 2008A) and approaches (Liniger et al. 2008B) are filled in together with local experts disposing of the necessary field knowledge. These studies are compared and analysed in terms of impacts on ecosystem services.

3.2.4 Data digitalisation

Once field-protocols, WOCAT-questionnaires and field-books are completed and land use is directly mapped on the print of a Quickbird satellite image, data have to be digitalised:

1) Field-protocols and WOCAT mapping questionnaires need to be digitalised. Data are introduced into Excel forms and can be summarised in Pivot-tables (generated by Excel): They constitute a summary of all columns' titles (LUS, indicator names...) and permit to hierarchically combine different indicators on the x-axis and the y-axis of a chart. The digitalised field-protocols are subject to statistical evaluation. Different statistical measures (such as average values and standard deviations) are extracted and represented in different types of charts (as for example pie diagrams and histograms) to show differences between LUS. If no data source is specified, all figures and tables are based on own data and all photos have been taken during the field-surveys in summer 2008 by the author of this study.

2) As far as the drawn LUS map is concerned, digitalisation appears to be somehow more complicated. But it is an important step towards GIS-modelling, since with a digitalised map a comparable unit with a modelled map is available. Unfortunately time for GIS modelling was not sufficient. The following steps are necessary for digitalisation:

- **Enhancement of georectification:** Bühlmann's (2006) georectification requires further ground-points, since most of the groundtruth points used by Bühlmann are on the margin of the study area: This leads to distortions, especially in the centre of the scenery. This is why during the field-stay in 2008 further 11 points, distributed over the whole study area, are registered by GPS. These points are attributed with coordinates and georectification on the basis of Bühlmann's satellite image is repeated.
- **Digitising LUS boundaries:** The printed map with the drawn LUS borders is scanned and a 200 dpi TIFF-file is created. This file is imported into Arc Map and georectified by a layer-to-layer transformation: For example crossing-points of roads on the scan, also recognisable on the satellite image, are attributed with coordinates of the georectified satellite image of Bühlmann (idem). Once the scan is georectified, a line-shape-file is generated in Arc Catalog. The lines drawn by hand are edited by using Spatial Analyst tools in Arc Map. After digitalising all lines and closing all the open polygons, the line-shape-file is converted into a polygon-shape-file. Where lines are not converted into polygons the remaining polygons are directly added into the polygon-shape-file. Then all polygons must be attributed: they must be provided with LUS information. The different LUS are then given colours which can be saved as a layer-file.
- **Digitising of sampling sites:** In a last step the coordinates of 80 sampling sites' centres are imported into Arc Map as an Excel-dbf-file and then exported as a shape-file. The graphical representation of the points permits to control whether all points are mapped in the LUS they belong to.

3.3 Plant-ecological methods

The basic units of vegetation description are normally plant communities, described as *"the collection of plant species growing together in a particular location that show a definite association or affinity with each other"* (Kent and Coker 1992: 14).

They are often distinguishable by different structures or colours and by other criteria. Colours indicate different species, but also differences in development stage. Vegetation description goes two different ways, which will be described in the following subchapters about floristic and structural methods (see Kent and Coker 1992, Dierschke 1994 or Tremp 2005). In any case, the goal of plant-ecological methods in this study is to obtain information on possible differences in vegetation composition under different management regimes (LUS).

The sampling design is based on the 80 sampling sites defined earlier. For structural data two transects (one in the N-S-direction and one in the W-E-direction) are laid through the sampling site's centre and a field assistant collects data along these transects. For floristic data a square-metre frame is placed four times, each time by walking 15 paths from the sampling site's centre towards the middle of one of the four quadrants formed by the two transects. There are two advantages of assessing structural indicators on a point-basis (transects) and floristic variables on a surface-basis (square-metre frames). Once it permits a division of labour with the field assistant responsible for transects and the author responsible for the square-metres. In addition the transects are also used as a delimitation of the sampling site-area that is used to assess other indicators discussed in chapter 3.4.1, not only for vegetation data.

3.3.1 Floristic indicators

Before starting site-sampling a decision has to be made on the vegetation patterns to be analysed. For floristics (plant systematics) in this study the main approach applied is plant palatability. It reflects ecosystem state and quality (see chapters 2.1.1 and 2.2.2). Therefore, palatability groups are defined together with land users. This permits to analyse, thanks to plant-surveys, whether for different LUS the proportion of palatability groups varies. In the field, species are assessed independently of the palatability-group they belong to. When analysing the digitalised tables (see chapter 3.2.4), the species are registered and attributed to the following palatability groups:

1) Non-palatable species: Plant species that are usually not grazed by sheep, goats and cows. They have either been classified as such by herders and specialists or they have been observed not to be eaten. Some of them are even poisonous;
2) Low-palatability species: These plants are not eaten by all domestic animals (mainly sheep, goats and cows). Or they are only eaten in wintertime as hay. They are often only partly grazed (for example only the leaves) or selectively used for haymaking, depending on the availability of good haymaking areas;
3) Medium-palatability group: These are the best available species, eaten by all animals. This does not mean that they are necessarily of high fodder-quality, but that they are better compared to other plants.

The plant surveys also allow other uses of plant-systematic data. An important indicator is the relative frequencies of annual and perennial plants, giving a general idea of pasture-quality. Medical plants play an important role in traditional medicine and also have an economic value (some of them are sold), thus their occurrence is recorded. The combination of these indicators, together with structural indicators, permits to see if the results of the single indicators are coherent (cross-checking).

The choice of four times 1 m^2 of vegetation is in accord with Kent and Coker (1992: 42) who propose quadratic sizes of 4 to 16 m^2 for grassland communities. The decision to analyse square metres of vegetation dispersed on the whole 900 m^2 will help reflect the small-scale differences in vegetation composition. For each quadrant a plant survey is made. The fractional vegetation cover of each plant species is noted, using a modified Braun-Blanquet-scale (Dierschke 1994: 272), as used in WOCAT-assessment, thus providing for methodological coherence. The categories are:

- <5%
- 5-15%
- 15-30%
- 30-50%
- 50-70%
- >70%

These same cover categories are applied for general cover estimations over the whole sampling sites. Pictures in the WOCAT SLM-manual help make such estimations (Grob and Gasser 2008: 9). For data-analysis arithmetic means of these classes are used, for instance 2.5% for the lowest class (<5%). For cover of different species per sampling site, again the arithmetic mean values of the four quadrants are taken, whereas for the frequency of species each quadrant is treated separately. The resulting values are taken as a measure of the total sampling site-area of 900 m^2.

3.3.2 Structural indicators

Structural data helps see whether certain life-forms predominate under different types of management. This gives indications on pasture-degradation, be it by the high proportion of trees showing tree encroachment, by the predominance of non-graminoids (forbs) at the expense of graminoids (which are of superior fodder quality) or by high structural diversity offering niches for animals.

The categories assessed are based on very simple life-form classifications (Kent and Coker 1992: *"Küchler's method"*: 32ff and Dierschke 1994: 101) and correspond to the vertical structure of typical grasslands. One species is always attributed to the same of the following life-forms, independently of height:

- Trees, especially *Crataegus sp.* and *Morus alba*;
- Shrubs, excluding subshrubs such as *Artemisia sp.* that are assessed as herbs;
- Herbs, subdivided into graminoids (grasses) and non-graminoids (forbs).

Thorny plants (trees, shrubs or rarely herbs) are simultaneously recorded as thorny plants. They stand for inferior fodder-quality.

Two 30 m measuring tapes are used for data collection along transects. Every metre the dominant structural type (tree, graminoid…) touching the measuring band is recorded, comparable with point-frequency assessments (Dierschke1994: 164ff). For data-analysis percent values are determined on the basis of 62 transect values and taken as a measure of the 30 by 30 m sampling site-area.

3.3.3 Vegetation indicators

An overview on the floristic and structural indicators is given in Table 3.

Indicator	**Measured variables**	**Sampling unit**
Floristic indicators		
Palatability groups	%-coverage and frequency	4 m^2 (four m^2 quadrats)
Dominant species	%-coverage and frequency	4 m^2
Medical plants	%-coverage and frequency	4 m^2
Annual / perennial plants	%-coverage of annual compared with perennial plants	4 m^2
Structural indicators		
Vegetation cover	%-coverage in the classes mentioned above.	4 m^2 and 62 m (transects)
Proportion of trees and shrubs	%-coverage, relative to total cover (100%)	62 m
Graminoids / non-graminoids	%-coverage of graminoids compared with non-graminoids	62 m
Thorny plants	%-coverage, relative to total cover (100%)	62 m

Table 3: Different plant indicators.

3.4 WOCAT Mapping and WOCAT-assessments at sampling site-level

In WOCAT assessments both the sampling site-level and the LUS-level are important. In this study for the sampling site-level different indicators proposed by WOCAT are assessed (see Grob and Gasser 2008) and for the LUS-level standardised WOCAT mapping questionnaires are filled in and (Liniger et al. 2008C), using the same indicators as on the sampling site-level. The information of the questionnaires is completed by interviews (see chapter 3.5).

The different types of WOCAT-indicators according to the DPSIR-framework (see chapter 2.2.1) will be addressed in the following subchapters. As for vegetation indicators and for all other indicators as well, the objective is to see if certain forms of degradation are LUS-specific.

3.4.1 State-indicators

Indicator	Measurement method	Measured variables	No degra-dation	Degree			
				Light	Moderate	Strong	Extreme
Compaction	Knife test: Penetration of the blade into the soil	Extent, degree	> 5 cm	3- 5 cm	>1-<2 cm	0.5-1 cm	<0.5 cm
Sealing and crusting	Hardness of crust, together with photos (Liniger et al. 2008D)	Extent, degree	No crust	Crust can be broken by fin-gers	Crust breaks up into crusty pieces	Crust can only be broken by pocket knife	N.A.
Reduction of vegeta-tion cover	Remaining cover	Extent, degree	>70% cover	30-70%	15-30%	5-15%	<5%
Quantity / biomass decline	Height and leafiness	Extent, degree	No signs of grazing or mowing	Signs of graz-ing / mowing	Mosaic of grazed or mowed patches	Plants grazed / mowed in majority	Plant height <5cm
Loss of habitats	Different vege-tation canopies (trees, shrubs, herbs)	Degree, (extent: 100%)	All struc-tures	Either trees or shrubs	Only graminoid and non-graminoid plants	Only graminoid or non-graminoid plants	Total cover <20%
Loss of soil life	Number of animal holes and heaps	Degree, (extent: 100%)	>40	20-40	10-20	5-10	<5
Loss of top-soil	Rills or pedes-tals occurring	Yes / no, extent	N.A.				
Gully ero-sion	All rills with at least 50 cm depth	Yes / no, extent					
Aridification	Yellow vegeta-tion or thorny plants	Yes / no					

Table 4: WOCAT state-indicators. For the fields with dark-gray fill-colour no information is available.

Besides the vegetation state-indicators already discussed in the previous chapter, other frequent degradation processes, defined by WOCAT-methodology, are assessed for the total of eighty sampling sites. For an overview of the assessed state-indicators see table 4. During the visual LUS classification (see chapter 3.2.1) a number of WOCAT-indicators are chosen and then reduced during data-analysis to a selection of degradation-indicators effectively found in the field, for which a coherent assessment method has been found. If possible, indicators are described with regard to:

- extent (5%, 10%, 20%, ..., 100%);
- standard deviation of extent (%) and
- degree (light, moderate, strong or extreme).

The indicator *"Loss of soil life"* is constituted by the count of any signs of animals: mainly anthills, but also mouse- and snake-holes, through the field assistant and on the whole sampling site-area. For ants their aerating function in soils is described in a manual of the Land Degradation Assessment in Drylands (LADA) (McDonagh et al. 2008: 83), whereas mice and snakes are generally considered as pests from the land user's perspective. But in this case, the method has to be simple. *"Loss of habitats"* is derived from vegetation structural data (see chapter 3.3.2).

3.4.2 Pressure-indicators

A whole number of possible degradation causes are distinguished (see table 5). Since grazing activity is the variable that can be changed (else than natural causes), a special focus is on population growth, livestock numbers and the herd composition. For these variables figures from the local statistical department for 2000 and 2008 are available (Jamoat 2008).

Degradation cause	**Degradation signs**
Overgrazing:	
• Excessive numbers of livestock:	High grazing pressure indicated by low-palatability species showing grazed leaves or stems; herd sizes indicated by land users.
• Trampling of animals:	Best reflected by the trampling-path density, together with the animals themselves.
Natural causes:	
• Change of rainfall patterns:	Lack of rain verified by asking land users; having similar effects as a drought and thus also detectable by aridity.
• Droughts:	Information of land users, confirmed by dried up soils and a high proportion of yellow plants that indicate the effect of droughts.
• Floods:	In the dry-season only proven unless by the effects of run-on.
• Topography / relief:	Steep slopes with south exposure and high radiation explaining why vegetation is often sparse in this case.
Run-on (from roads. settlements, paths or from other fields):	Onsite accumulation of material from nearby fields and paths showing past run-on; nearby gullies or rills indicating that the cause of sedimentation is run-on.
Lower infiltration rates:	Often co-occurs with soil crusting, since a hard crust prevents water from infiltration; missing animal-holes reduce infiltration.
Signs of previous tillage:	Plough horizon or line or past tilling confirmed by land users.

Table 5: Major degradation causes and how they are detected.

3.4.3 Response indicators

Different forms of management are analysed as to extent (categories: 5 %, 10%, 20 %, …, 100%) and effectiveness, per LUS (low, moderate, high, very high) (see table 6).

Conservation measure	**Effectiveness**			
	Low	Moderate	High	Very high
Structural and vegetative measures				
Vegetative strips	Some or all planted trees dried out.	Fruit harvest reduced due to young or sick trees.	Trees in a middle age, providing for combined fruit and hay harvest.	Very high cover with mixed tree-varieties.
Terraces	Little effect on slope reduction and improvement of drainage, often with narrow terraces, or not maintained, old terraces	Rather wide terraces provided with drainage ditches	Either wide or slightly backward-sloping and thus better retaining floods; were maintained.	Big effect on slope reduction; wide, recently maintained terraces, (not seen).
Grazing land management measures				
Controlled grazing periods	Long grazing periods; animals frequently passing without grazing for a long time or staying in the shade of trees (with reduced cover) at noon-time.	Fixed grazing periods with grazing in the driest summer months, often in haymaking areas	Short grazing periods of days, often with professional herding.	Absolutely no grazing.
Controlled livestock access	Access only controlled from one or two sides, by people or fences.	Controlled access through fences; animals not enough supervised.	Enclosure from all sides, with stable (metal), tall and / or small meshed fences	Haymaking areas, not accessible for livestock due to gullies
Reduced livestock numbers	Steep areas that can only be grazed by goats	Distant pasture areas, only visited by little herds	Rented land or research-areas, where grazing is forbidden without control or where only the animals of the herder graze.	Fix stocking rates, externally controlled (not seen)

Table 6: Conservation measures and their effectiveness

3.4.4 Impact indicators

Ecosystem services (ESS) shall be considered as a result of state indicators with their negative, respectively positive impacts. This means that ESS values are considered as a consequence of land use, not taking into account the fact that current land use again has repercussions on future management options. The indicators presented in table 7 are the most important indicators used to assess ESS in the field. Most indicators only have positive or negative impacts, except for natural trees that can have a negative impact on productivity, besides their many positive impacts.

Positive impact indicators	Effect on Ecosystems
Terraces	• Reduction of slope; • stopping runoff.
Fruit trees	• Size, number and use of fruits indicate productivity; • efficient against aridification.
Haymaking	• High plant diversity; • high production.
Natural trees or shrubs	• Additional cover canopy stops rain; • retaining moisture; • ecological niche; • maintain soil structure; • wind-barriers. • trapping sediments (floods); • wind-stopping and retaining moisture. • Negative for productivity: bush encroachment.
Palatable, green vegetation	• Indicate high fodder-quality; • Indicator for soil-moisture; • Often close to waterways.
Chocolate to blackish soil-colour	• Indicates fertility.
Negative impact indicators	
Cover-reduction	• Soil-protection destroyed; • stopping runoff effect away; • provides material for organic matter formation; • cover important for microclimate regulation.
Reduction of biomass	• Indicates fodder-quantity; • biomass retains runoff; • as cover indicator.
Compaction	• Less infiltration / water-storage capacity and pores.
Loss of topsoil	• The organic layer is first transported away; • reduces vegetation-cover.
Crusting	• Reflects reduced infiltration capacity and soil structure.
White soil surface	• Shows a lack of organic matter; • Stands for hard, washed and dried out soils.

Table 7: The different indicators defining ecosystem services.

In order to develop a quantitative calculation algorithm for ESS, the impact of the indicators from table 7 on selected ESS is described (see table 8). The ESS *"Production"* and *"Water quantity and quality"* are considered as productive functions, whereas the rest of the indicators can be subsumed as ecological functions (see chapter 2.2.2). Hereby each indicator is assessed with regard to its impact on the different ESS, on a scale from -3 (very negative) to +3 (very positive) (Liniger et al. 2008C). The impact of the indicators is judged compared with the situation without the indicator.

ESS values are calculated by taking all the occurring indicators. Indicators with data on the extent and degree are only considered in case of a minimal extent of 30% of the sampling site and of a degree of at least *"moderate"*. More general indicators, for example soil-colour, are considered if they occur. The calculation algorithm developed permits a comparison of ESS assessed in the field with calculated ESS.

Different measures of the calculated ESS are taken, as an answer to objective 3:

- The arithmetic average of all the positive and negative indicators' impacts is calculated for each of the 80 sampling sites and summed up as a synthesis.
- The sum of both the positive and negative indicators' impacts is calculated to see how many indicators contribute to positive and negative ESS values. The values are summed up to see if there is a net positive or negative impact.
- The aggregated value per LUS is the average value of the ten sampling sites per LUS.

	Production	Water quantity /quality	Flood-regulation	Drought-resistance	Organic matter	Soil cover	Soil structure	Biodiversity	Micro-climate
Positive impact indicators									
Terraces	+ 2	+ 2	+ 3	+ 2	+ 1	0	0	+ 1	+ 1
Fruit trees	+ 3	- 1	+ 1	+ 1	+ 2	+ 2	+ 1	+ 1	+ 3
Haymaking	+ 2	+ 2	+ 2	+ 2	+ 2	+ 3	+ 2	+ 3	+ 2
Natural trees or shrubs	- 1	+ 1	+ 2	+ 2	+ 2	+ 2	+ 2	+ 3	+ 3
Palatable and green vegetation	+ 3	+ 1	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2
Chocolate to blackish soil-colour	+ 3	+ 1	+ 1	+ 2	+ 3	+ 2	+ 3	+ 1	+ 1
Negative impact indicators									
Cover-reduction	- 2	- 2	- 2	- 3	- 3	- 3	- 2	- 2	- 2
Reduction of biomass	- 2	- 1	- 2	- 2	- 1	- 1	0	- 1	- 2
Compaction	- 2	- 2	- 3	- 2	- 2	- 1	- 3	- 2	0
Loss of topsoil	- 2	- 2	- 3	- 2	- 3	- 2	- 2	- 1	0
Crusting	- 2	- 2	- 3	- 3	- 3	- 2	- 3	- 3	- 2
White soil surface*	- 3	- 1	- 1	- 3	- 3	- 2	- 3	- 2	- 1

Table 8: Positive and negative impact indicators, in collaboration with Liniger (2009). The indicator with (*) is judged by the use of photos.

3.5 Interviews

The interviews can be subdivided into land user and key informant interviews with a fluent transition between the two categories. Both types are examples of semi-structured interviews as described in a LADA manual (McDonagh et al. 2008: 104f). And they both face questions such as:

- The utility of different LUS in productive and ecological terms;
- Land use changes in space and time, as for example the transition from one LUS to another;
- Animal husbandry as an important part of livelihoods.

3.5.1 Land User interviews

In order to complete case studies (see objective 4) land user interviews (idem: 50f) are conducted. The questions are defined on the basis of two standardised questionnaires:

> *"The Questionnaire on SLM Technologies addresses the following questions:* ***what*** *are the specifications of the Technology, and* ***where*** *is it used (natural and human environment), what impact does it have"* (Liniger et al. 2008A: i)".
>
> *"The questionnaire on SLM Approaches addresses the questions of* ***how*** *implementation was achieved and* ***who*** *achieved it"* (idem: 108).

The following approaches and technologies are assessed in the case studies:

- Daily and seasonal rotation (technology) with seminomadic grazing with professional herder (approach);
- Orchard with combined structural and management measures on research territory (technology) with semi-public integral landscape management (approach);
- Orchard on marginal cropland (technology) with individual rehabilitation initiative (approach) and
- Seasonal rotation and double-use of land by two herds (technology) with farmers' associations-controlled herding (approach).

3.5.2 Key informant interviews

Case studies are mainly based on statements of individual land users, complemented by information of local leaders and experts from land administration (idem: 108). These interviews are important to understand the indirect drivers of land degradation (see chapter 2.1.1) and the options to complement bottom-up conservation measures by top-down land use regulation. They are also necessary as a substitute for own observations on the different LUS and thereby helpful to complete WOCAT mapping questionnaires (Liniger et al. 2008C).

The interview partners are village-chiefs or other experts (leaders, teachers, wardens) of 9 villages in the study area, land-use administration on different levels (village, local and district) and the forestry department on the district level.

4 Results

As a response to objective 1, a delimitation of the different mapping units is given in a map (chapter 4.1). Next, pasture, cut and carry, and mixed LUS are described in detail (chapters 4.2 – 4.5). Besides the described LUS, two further mapping units were assessed: cropland, which is not the focus of this master's thesis, and so-called barren areas (see figure 7). They are not used for grazing or fodder-production because they do not offer much to eat. Sometimes goats and sheep cross them to pass from one pasture area to the next one, or people collect (parts of) medical plants, especially almonds. But often barren areas are too rocky and steep to be crossed either by humans or by domestic animals.

The description of each LUS gives responses to objectives 2 and 3 and comprises:

- The status of each LUS in terms of degradation vs conservation;
- Dynamics are reconstructed thanks to land users' testimonies. The focus is on changes in time; where possible spatial dynamics are also discussed;
- Conservation is more generally talked about to see if considerable differences in type and extent of conservation strategies exist for different LUS;
- Impacts both of degradation processes and conservation measures are measured as impacts on ESS.

After the LUS descriptions specific case studies about management measures are compared in view of answering objective 4 (chapters 4.6 and 4.7).

4.1 Digitised LUS Map with characterisation

In figure 7, digitalised Land Use Systems (LUS) and sampling sites covering a great part of the study area are depicted. The border of village-controlled territory with forest administration is indicated by the red line. A visual representation of the LUS is given in figure 8.

Because the area is partly under forest administration and under the district-level land administration, both administrations charge rent fees for their land separately. In the case of the district-administration, each village has to pay a fixed amount per ha depending on land use (see table 9). It autonomously decides how to charge these fees for pastures and haymaking areas to land users.

Land Use category	**Rent fee per ha [$]**
Cropland irrigated by flooding	30.1
Cropland irrigated by pumps	21.9
Rainfed cropland	7.6
Grassland	1.3
Farmers' associations	0.4
Marginal areas	0.8

Table 9: Land rent fees paid to district tax department (Jamoat 2008).

The clear borders between pasture use and cut and carry LUS often follow the borders of one ridge to the next one (see chapter 1.2). These borders are also visible by the LUS *"Marginal areas"* which is situated close to rivers. And, of course, a river always separates two ridges.

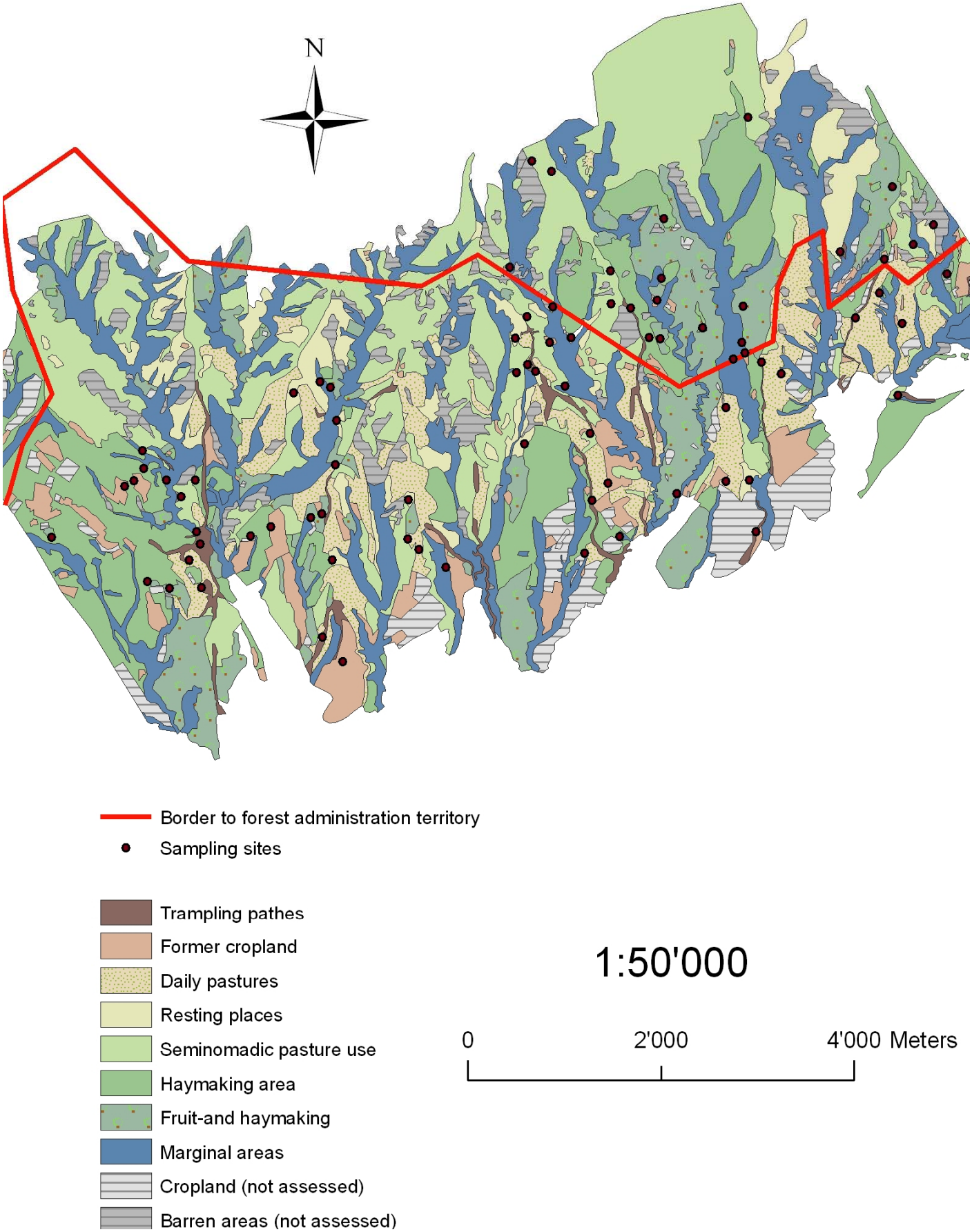

Figure 7: The LUS are sorted from low (brown colours) to high cover values (green colours). The border to forest administration is based on a map from FAZO Institute of the Land Management Agency 2003).


Trampling path


Daily pastures


Resting place


Seminomadic pastures


Former cropland


Marginal areas


Haymaking area


Fruit and haymaking area

Figure 8: The different mapped LUS.

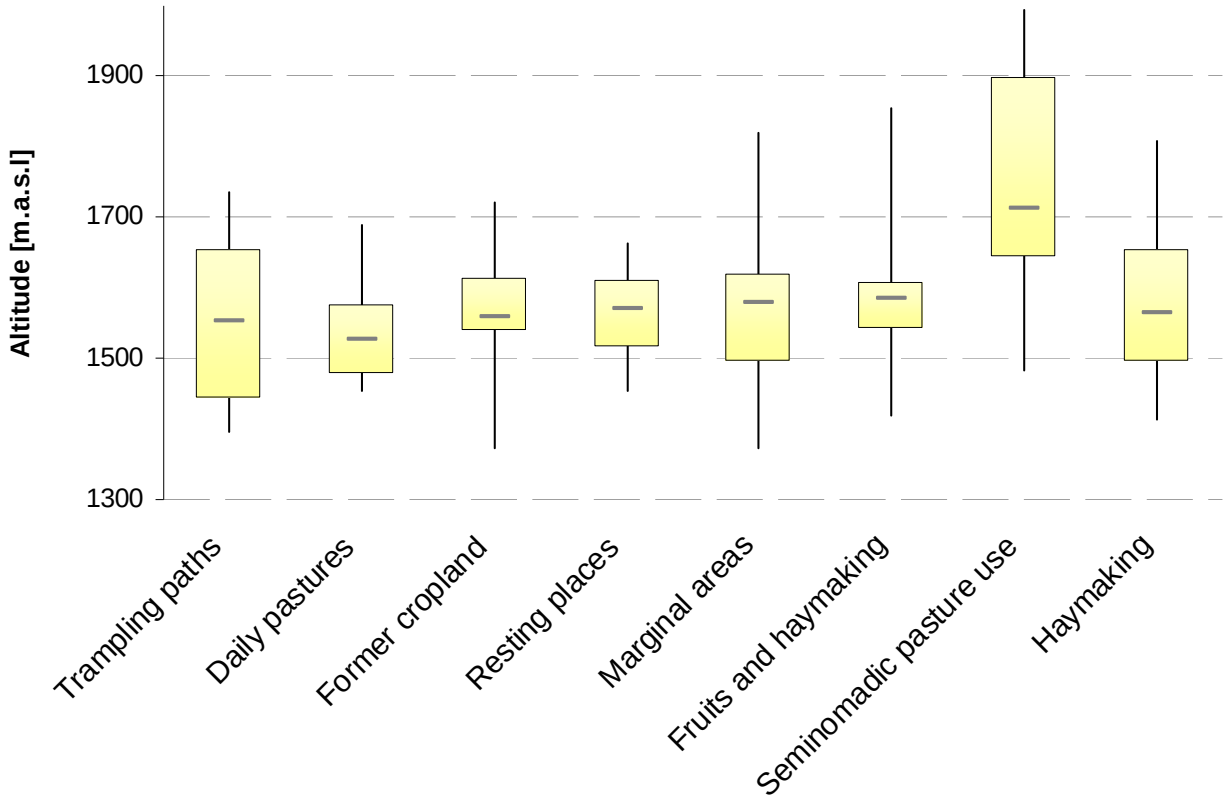

Figure 9: Average altitude of different LUS, according to zonal statistics.

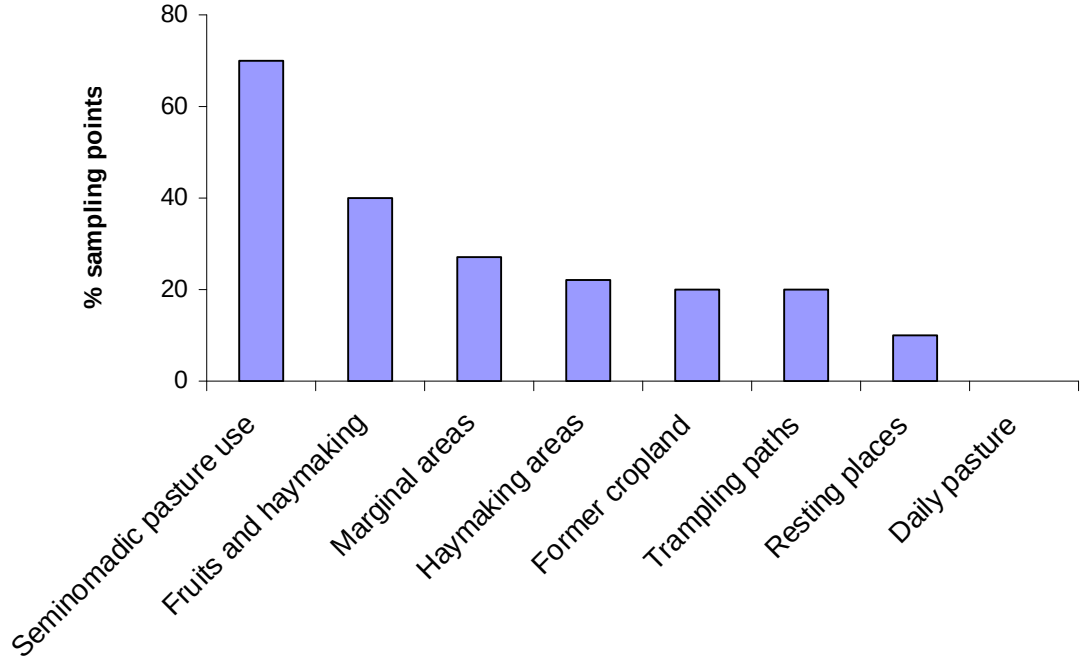

Figure 10: Relative number of sampling sites on forest administration territory.

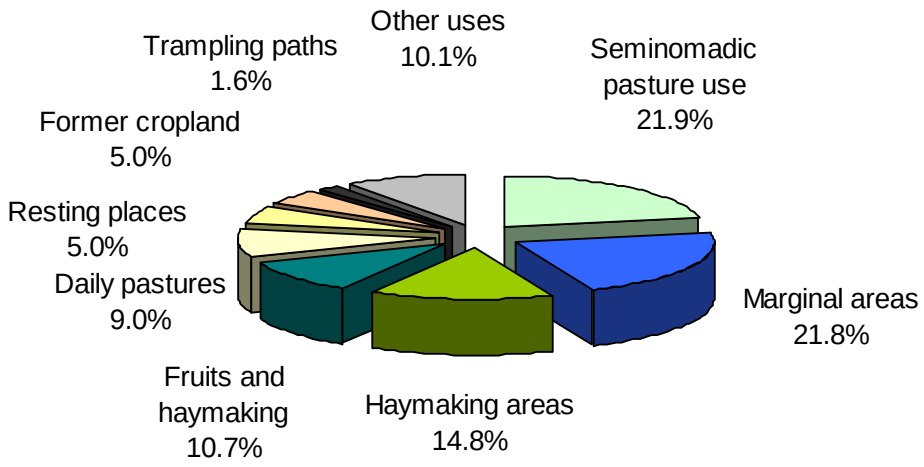

Figure 11: Spatially dominant uses in relation to total surface.

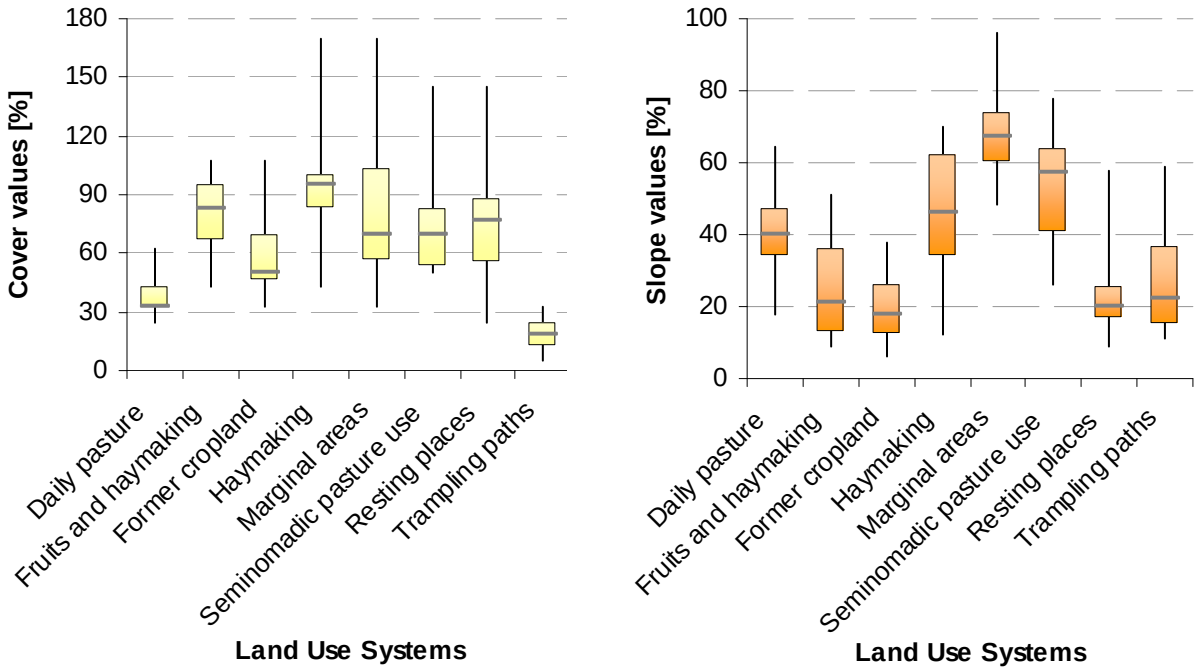

Figure 12: Average cover (left) and slope values (right) for 80 sampling sites. Cover values can reach more than 100% since several layers of vegetation including mulch are added to each other.

The pasture use systems *"Daily pasture"* and *"Trampling paths"* standing for generally more degraded areas are often closer to villages than the other LUS with less degradation phenomena. This is also indicated by the average altitude (figure 9), though it is highly varying among the different LUS: Standard deviations of altitude range from 68 m (resting places) to 163 m (seminomadic pasture use).

The sampling sites are quite regularly distributed over the assessment area (see figure 7). Still, it cannot be neglected that for more distant areas not the same spatial coverage is given as for areas close to villages. Furthermore, it is clearly visible on the map that the part of forest administration assessed is nearly not used as daily pasture area. In figure 10 this is shown by the relative number of sampling sites per LUS lying in the territory of forest administration. There is a high proportion of seminomadic, marginal and areas used for haymaking (and fruit-production).

As far as the share of different land uses over the whole assessment area is concerned, uses with little degradation phenomena such as seminomadic pasture use or haymaking prevail over highly degraded areas (daily pastures and trampling paths). The LUS with a high spatial extent in many cases have high cover values, whereas low-cover LUS are relatively small (see figure 11). But high cover is not a guarantee for good conservation state. Slope is important for the occurrence of erosion processes. And for many LUS with high cover slope values are high too (see figure 12).

Next it shall be verified whether the sampling site information represents well the rest of the assessment area and thus, if values from the points can be extrapolated to the surface. Therefore digital cover (see information about the OSAVI-index in chapter 3.2.1) and slope information is needed. Slope values are based on a digital elevation model applied by Bühlmann (2006: 11-12). For both data types average values per LUS can be extracted, both on the level of sampling sites and on the level of the polygons depicted in figure 7). Then a linear regression between the slope and cover values on the sampling site and on the polygon (LUS unit, as shown in figure 7) level is performed (see figure 13). It shows that the extrapolation of sampling site values onto the whole assessment area is supportable for the OSAVI-index (R^2 = 0.91), but difficult for slope (R^2 = 0.52).

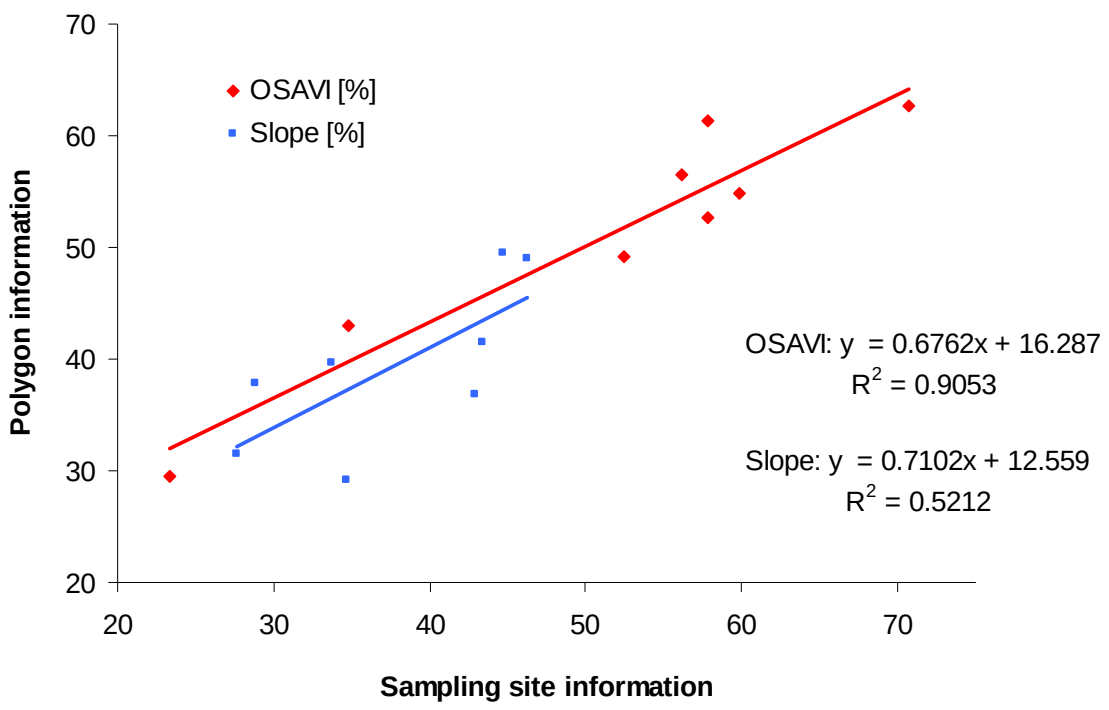

Figure 13: Linear regression of OSAVI and slope between sampling sites and polygons, per LUS.

4.2 Pasture areas

Areas exclusively dedicated to pasture use cover more than one third or 16.45 km^2 of the total assessment area (43.73 km^2). The different LUS in the pasture-area are discussed separately. A special focus is on livestock numbers which are in many cases the drivers of degradation: by the trampling of animals. Besides the drivers associated with water availability (droughts and rainfall patterns) overgrazing is the most frequently noted degradation cause (see figure 14).

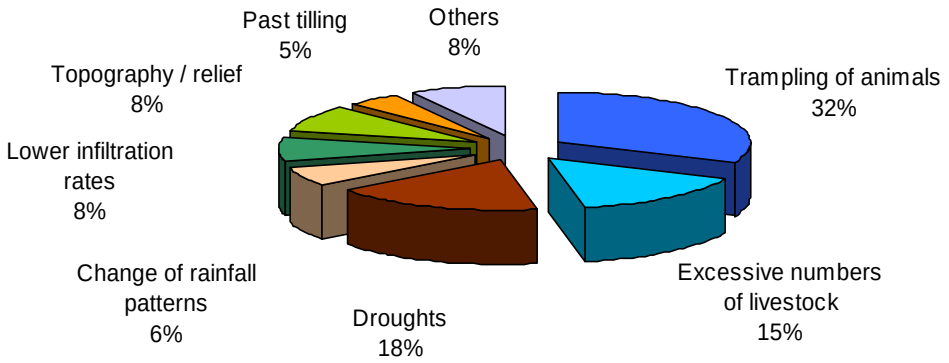

Figure 14: Major degradation causes, based on the 80 sampling sites.

4.2.1 Trampling paths

Trampling paths are linear landscape elements, recognisable from far away by very low values of vegetation cover, white soils and rills or gullies. They are often close to villages. Regularly animals are brought to the pasture-areas on these paths.

Trampling paths are heavily degraded, with a degradation degree of moderate to strong predominating and a total extent of at least 40% for most indicators (see figure 15). Physical (compaction, crusting) and degradation by water all show high degradation extents. The summed up extents of all sampling sites for gully erosion yield the highest value of all LUS. For the indicators of biological degradation *"Cover reduction"* and *"Biomass reduction"* degrees are high. And for *"Loss of soil life"* and *"Habitat loss"* the most frequent degradation degree is even the extreme degree.

Plant diversity is low, with only slightly more than the half of all species from the palatability groups (mentioned in chapter 3.3) occurring. At the same time species from the non-palatable and the low-palatability group together show higher frequency and cover values than the species of the best fodder-quality, which is exceptional (see figure 16). The thorny species *"Misvok"* (local name) and *Eremostachys lehmanniana*, but also representatives of *Artemisia sp.* are especially frequent on trampling paths and daily pastures (see also figure 20).

This means that this LUS is confronted with serious degradation. Figures from the local statistical department show a sharp increase of livestock numbers in the post-war years (see figure 21). According to land users this has led to a pressure increase on these paths. They especially mention a strong increase in biomass reduction and crusting. Only the occurrence of thorny plants has decreased, according to an expert.

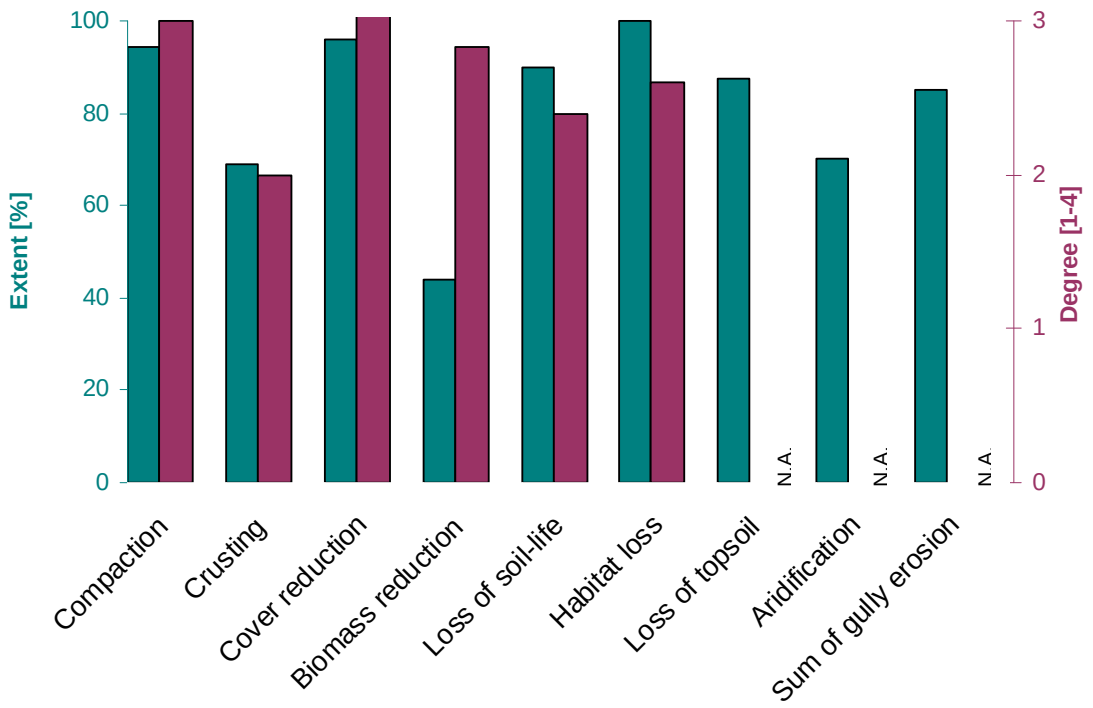

Figure 15: Extent and degree of different degradation indicators, for trampling paths. For some indicators data on the degradation degree are not available (N.A.).

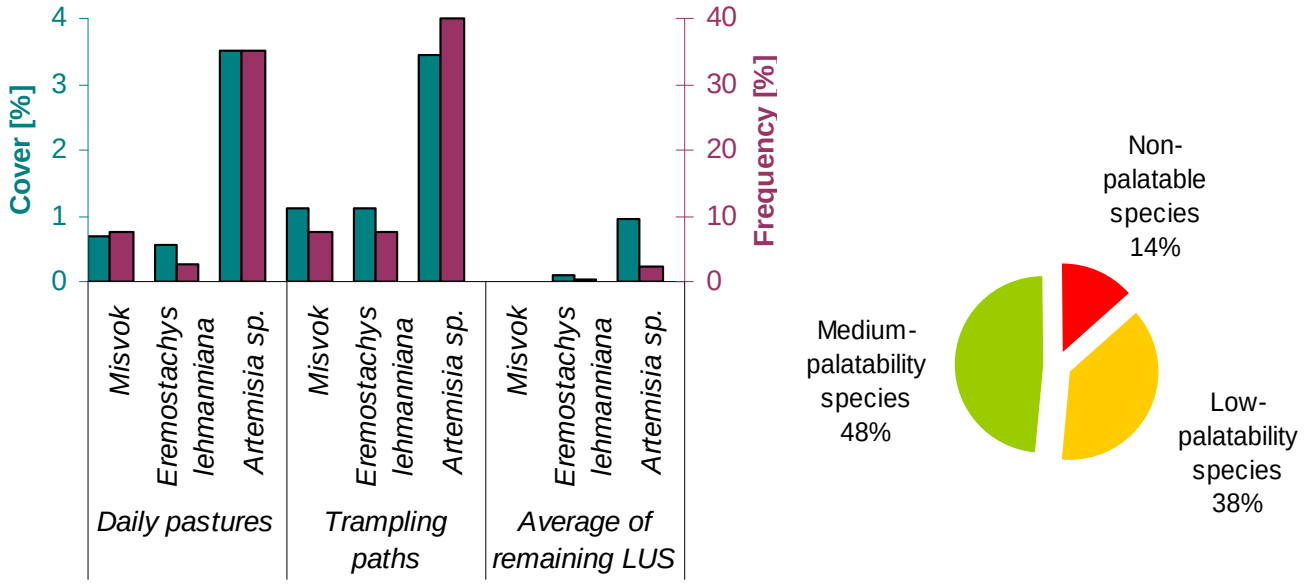

Figure 16: Three frequent non-palatable species (left) and the distribution of palatability groups (right).

There have been conservation attempts by the soil institute of Tajikistan, trying to fence trampling areas and to sow grass species. This has not led to a decrease of trampling paths, except for a few individual conservation initiatives. A villager says that he has been renting land for a few years on a former trampling path and that it has recovered thanks to high labour inputs and tree-planting.

Besides this villager, only a few examples of trampling paths are found where trees have been planted. Tree-planting reflects in a positive impact on ESS services, especially on microclimate, both for values assessed in the field and calculated values (see figure 18). As far as the impacts of degradation are concerned, all values are highly negative. This is a result of high extent and degrees of degradation. Indicators such as production and biodiversity are strongly affected by the depleted, white soils. But certain calculated ESS values such as for water quantity and quality are much less negative than those assessed in the field. In some cases mouse heaps next to trampling paths even indicate soil life (see figure 17). All in all, net values – built by adding negative effects of degradation to positive effects of conservation – are negative for all ESS.

Figure 17: Mouse heaps at the edge of a trampling path.

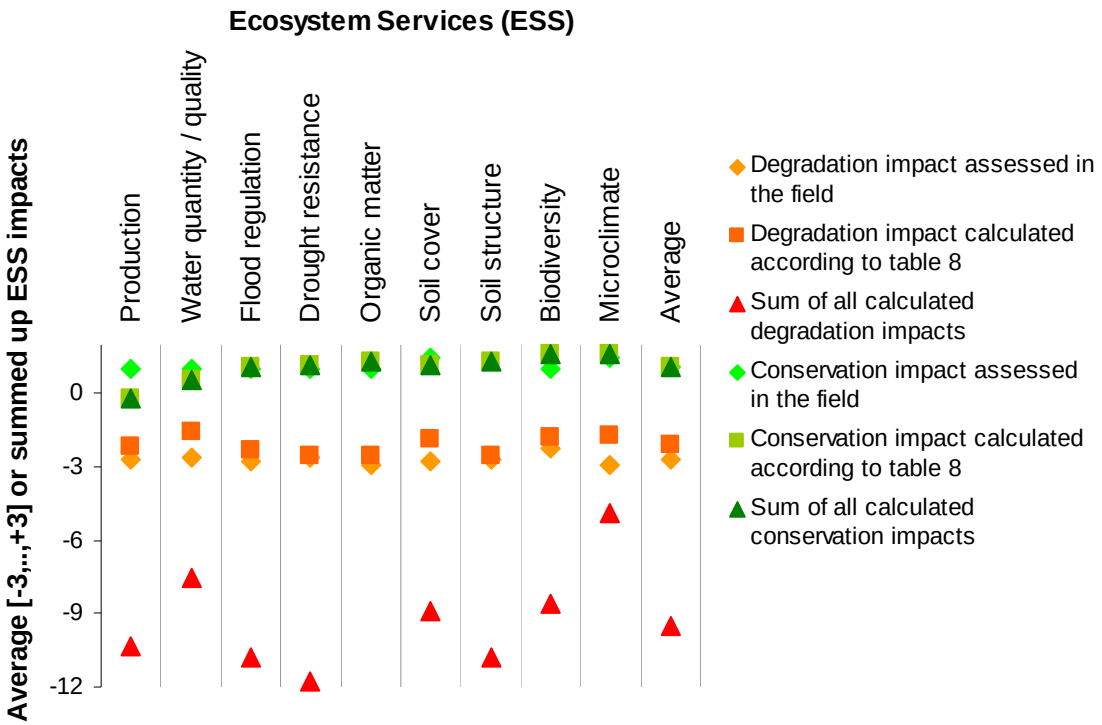

Figure 18: Positive and negative impacts on ESS, for trampling paths.

4.2.2 Daily pasture

This pasture-type is generally found on village-controlled land and is mostly grazed by a communal herding system. It is tightly associated with trampling paths crossing the pastures. Low cover values are the most characteristic feature of this LUS.

Figure 19 makes visible that the differences in degradation are small, compared with the previously discussed trampling paths. The higher extent of biomass reduction and compaction are compensated by lower degradation degrees. Generally, the extreme degradation degree has less spatial coverage. For the two indicators of animal life (loss of soil-life and of habitats) moderate degradation is more and extreme degradation less represented than for the latter LUS, whereas biodiversity is nearly the same. Vegetation degradation is clearly visible by high proportions of non-palatable species such as *Artemisia persica*, which give the pastures a slightly bluish colour (see figure 20).

According to data on degradation causes high livestock numbers can be made responsible for biological degradation (cover or biomass reduction), whereas physical degradation of soils (crusting and compaction) largely is a consequence of trampling. Together, these two forms of overgrazing are much more frequently enumerated as degradation drivers in daily pastures than natural causes such as droughts. Livestock numbers are thus important drivers.

The evolution of livestock numbers was a function of agricultural policies during former Soviet Union. Local leaders mention the severe regulation of private livestock numbers in the period from 1961-1975, whereas towards its end the USSR was more permissive. After independence the number of animals was reduced by the chaos of civil war. In some villages there were no longer any village herds and only a few rich tenants kept on herding. Many people sold their animals because of insecurity and in order to buy food: at times 50 kg of wheat would cost two cows.

It was after the end of civil war that people began to buy and breed animals again, which explains the quasi explosion of livestock numbers in the last years. Livestock numbers nearly doubled in eight years and in some villages surpassed the number of habitants (see figure 21). But still livestock numbers seem not to have reached the high levels of the Soviet era. The annual increase in livestock numbers of nearly 10% and the increase of herd sizes are in contrast to an annual population growth of 1.4% (between 2000 and 2008). But population growth was somehow exported: many young men migrate to Russia where they settle down, often with a Russian wife.

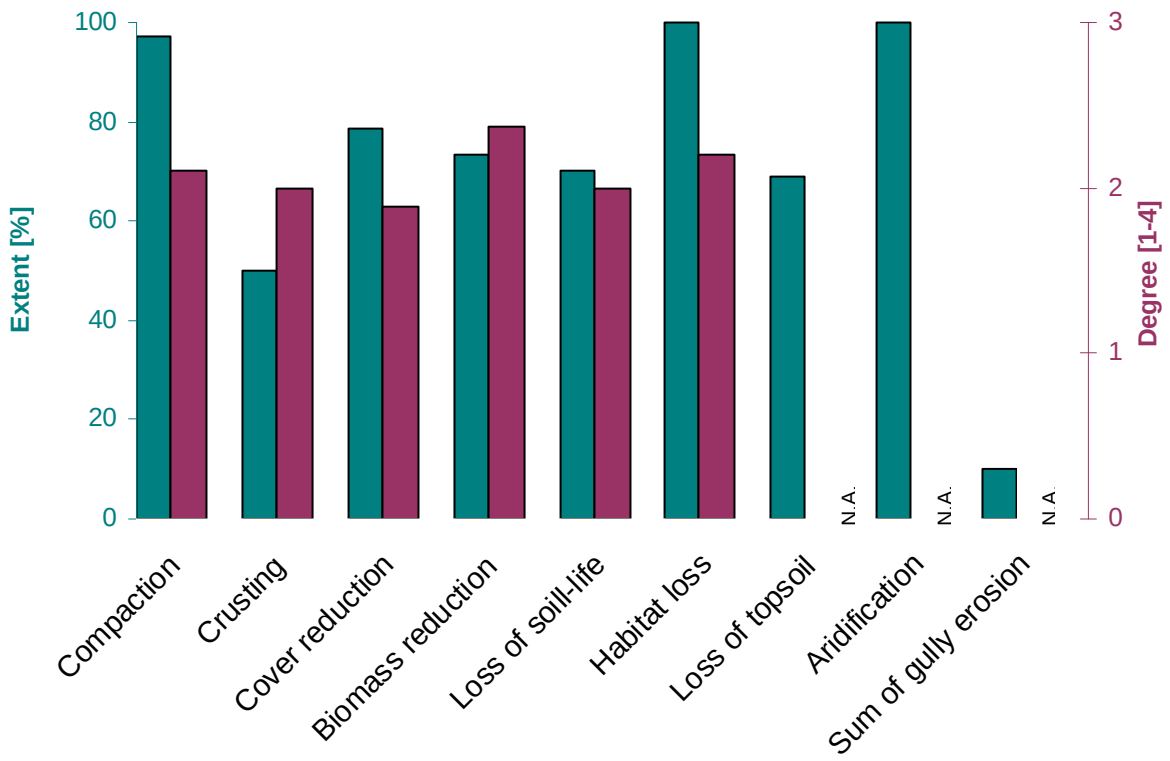

Figure 19: Extent and degree of different degradation indicators, for daily pastures.

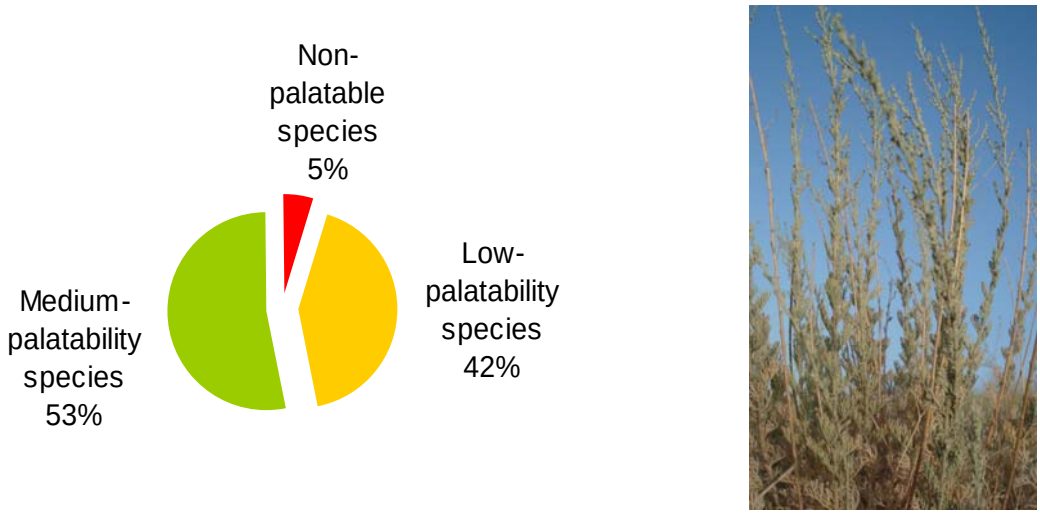

Figure 20: Palatability of vegetation on daily pastures (left) with the frequent species *Artemisia persica* (right).

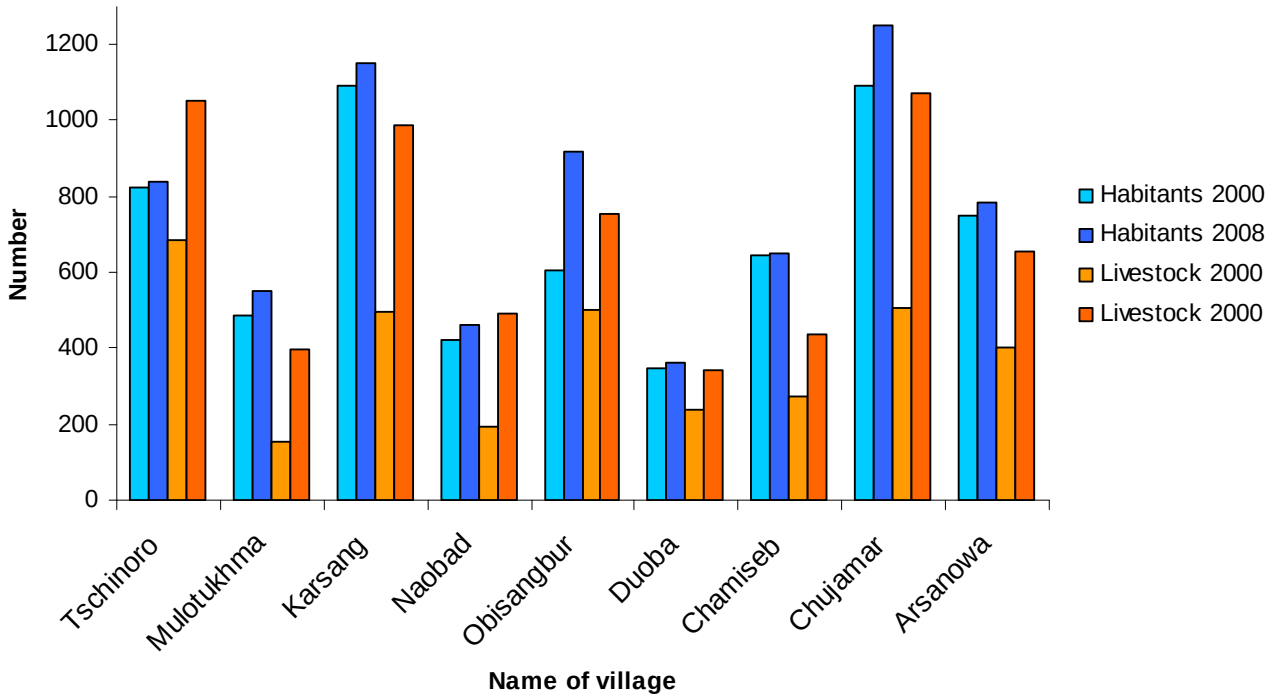

Figure 21: Evolution of the number of habitants and livestock in the study area (figures from Jamoat 2008).

Figure 22: Cow dung made to *"Tapak"* (plates) and dried for burning.

As the village herds are often grazed on the pastures mapped as daily pastures, which only constitute one fourth of the total pasture area, a deterioration of pasture state seems to be inevitable with increasing animal numbers. Effectively a local leader estimates that the values of most degradation indicators have severely deteriorated in the last years. A further problem intensified since independence is fertility decline. It is found in all LUS, but is especially present on daily pastures. This is due not only to the lack of fertilisers that used to be transported to the pastures by trucks for free, but also because of the use of animal dung as an energy source. Dung is collected by the children from the nearby villages, shaped to a kind of plate together with straw or charcoal and then dried (see figure 22) to be used for heating and cooking in winter.

Degradation also has to do with a decrease in the surface of such pastures, mentioned by several land users. Who could afford to rent land on the long term by building up a farmers' association would do so in order to establish orchards or to increase the surface of hay-production. This means that on former village pastures other land use categories have emerged.

Efficient conservation measures have not yet emerged on the pastures. The rotational scheme applied by the villagers is generally simple and its implementation is not strictly controlled (see chapter 4.6.1). The few trees and shrubs having escaped chopping together with slightly blackish soils in a few areas are the only positive state indicators. They lead to positive impacts on ESS, as can be seen in figure 23. In the field, no conservation measures as defined in table 6 could be found. The impacts of degradation indicators are far bigger than the positive impacts on ESS. Especially organic matter is strongly negatively affected by soil degradation, whereas the availability of water, which is in most places a scarce asset, is less affected. For microclimate results strongly differ between very negative values from the field and the slightly negative sum of calculated degradation and conservation impacts.

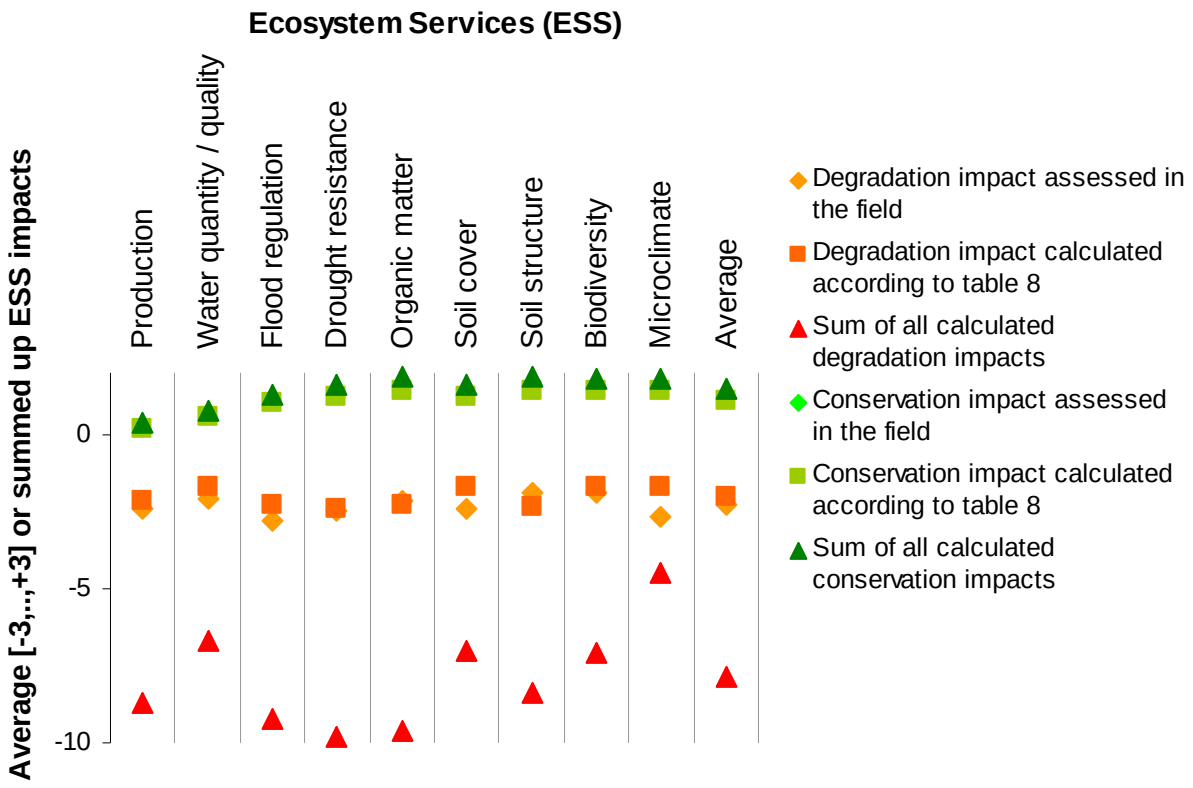

Figure 23: Positive and negative impacts on ESS, for daily pastures.

4.2.3 Resting places

Resting places are often used during the hot period of the day for animals to have a rest, as the name suggests. The most characteristic visual attributes are short vegetation, dominated by the grass *Cynodon dactylon* (see figure 24), and mulberry or other trees, which animals use as shade. Besides being a stress-resistant grass, *Cynodon dactylon* is an indicator of soil fertility. As animals rest in these places, they drop a lot of manure there, contributing to fertility. In addition this LUS is often found in relatively flat areas, often in former villages, where animals were probably kept in stables and thus their dung could accumulate. Cover values range from moderate to high.

As far as degradation is concerned, for many indicators the light or moderate degrees prevail (see figure 25). But both for the reduction of biomass and compaction strong and even extreme degradation occur. The hard soil and the low vegetation level are also reflected in the animal life indicators: There is little space for soil animals and even less space for life-forms living from structural diversity, as is visible by the high extent of habitat loss.

Land users say that degradation has changed little in these areas: *"Where there was Agirik 50 years ago, there will still be Agirik in 50 years"*, says a local expert. Resting places have not become bigger which implies that the increasing livestock numbers made land use intensity increase. This is reflected in the observation of a land user that the rate of biomass reduction is increasing for recent years. A striking change that is confirmed by elders is the clipped wool lying around trees (see figure 26). It used to be collected by state cooperatives to be processed into wool products. This industry broke down and nobody is collecting the wool anymore. An investor for a wool factory did not invest because of high taxes.

From the conservation measures found on resting places, most are grassland management measures according to table 6: For five from ten sampling sites controlled grazing periods or, with less spatial extent, controlled livestock numbers, are found. When the two measures are combined, an effectiveness class of moderate to strong is reached. Compared with daily pastures the control is often only limited, in the sense of limiting grazing times on the resting time when animals pass or of limiting herd sizes because the pastures are too distant for village herders and only some individual herders make the way up to remote pastures with their private herd.

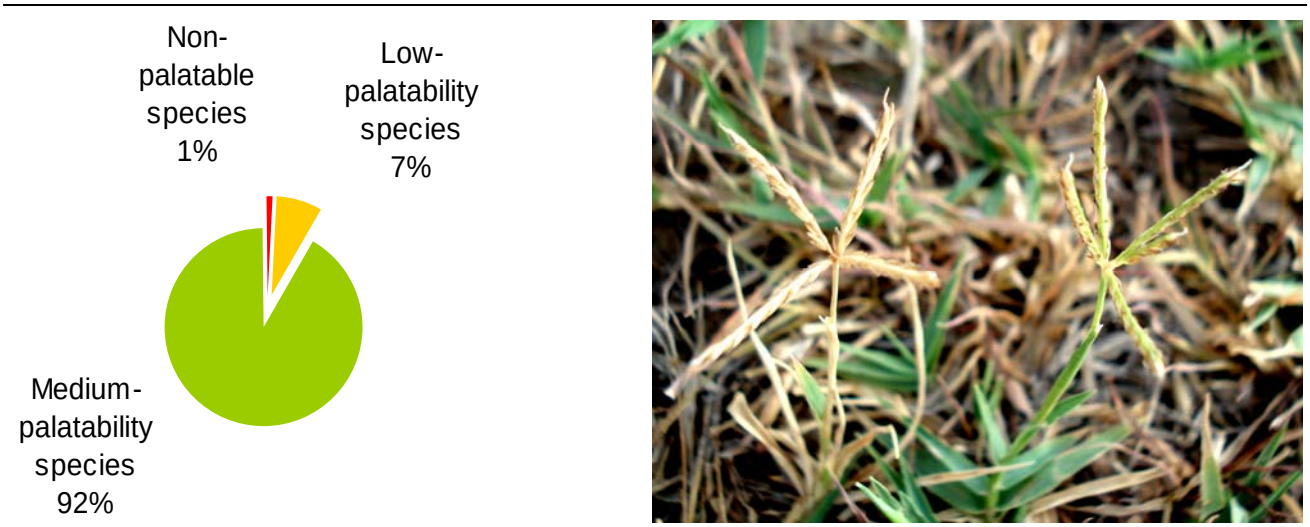

Figure 24: Palatability of vegetation (left) with the dominating grass *Cynodon dactylon* (right).

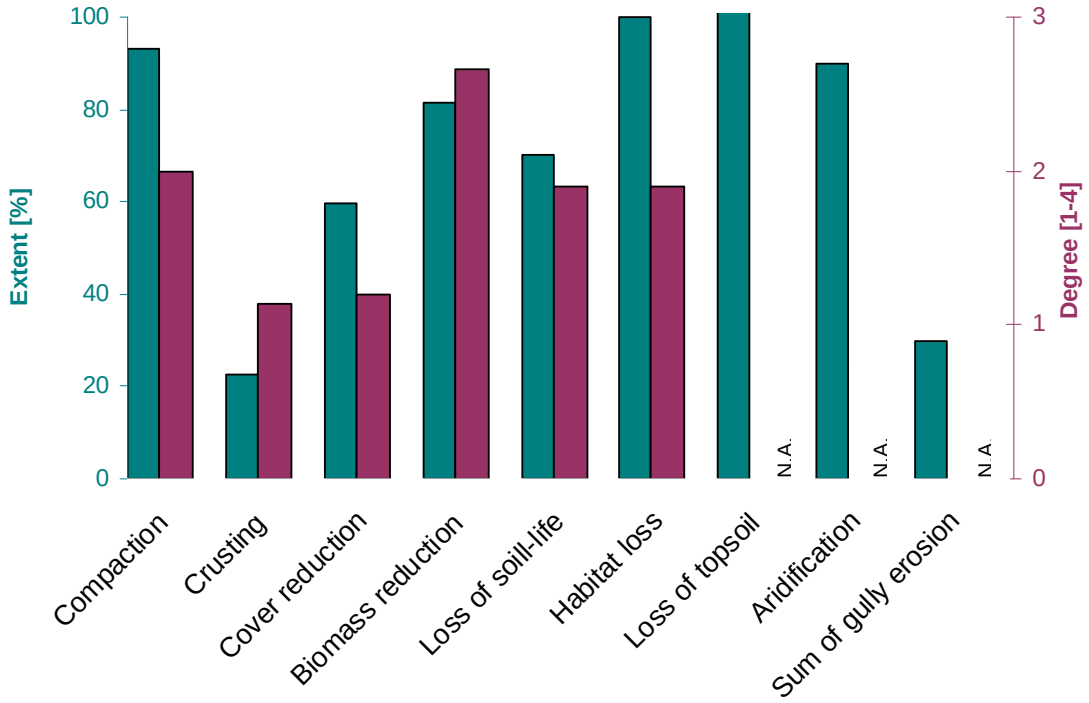

Figure 25: Extent and degree of different degradation indicators, for resting places.

Figure 26: Clipped wool in the shadow of mulberry trees.

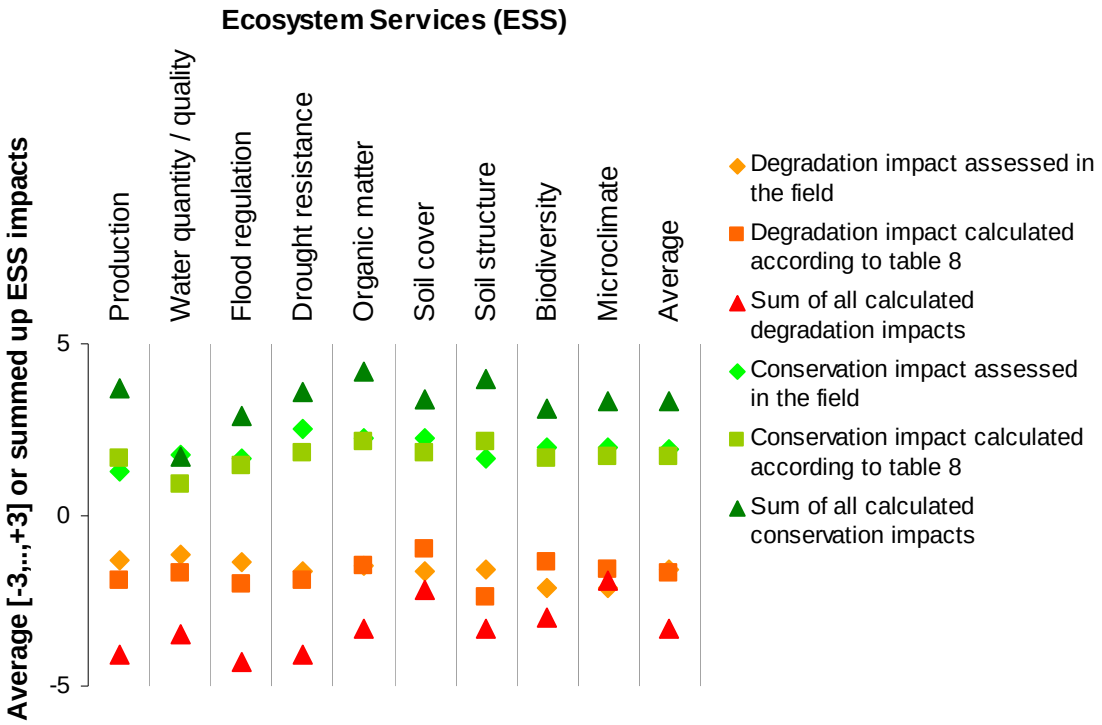

Figure 27: Positive and negative impacts on ESS, for resting places.

Besides grassland management, trees are also important for positive ESS values, especially of ecological ESS, for example by improving soil cover. Planted (often mulberry trees) or natural trees and shrubs are found on seven from ten sampling sites. If the average values of conservation and degradation impacts across all ESS are summed up a value of approximately zero results. But not for all ESS negative and positive impacts are balanced: Whereas the effects of (soil) degradation on organic matter are moderately negative, both calculations and field assessments of ESS reveal a very positive effect of often blackish soils on this ESS (see figure 27). There are ESS for which not the same values are assessed in the field as calculated on the basis of conservation and degradation indicators: field observations yield much more negative degradation impacts on microclimate than calculations. And the calculated strongly positive impacts of green, palatable vegetation and often black soils on production contrast with slightly positive values for this ESS from the field assessment which also takes into account (generally reduced) biomass besides palatability.

4.2.4 Seminomadic areas

Seminomadic pastures are mostly large areas at some distance from villages, many of them on forest administration land. They are often used by professional herders in summer. Seminomadic areas normally have high cover and slope values and typically contain a high proportion of non-graminoids such as Thyme and rather low cover values for good fodder-species (see figure 29). Except for the local herder interviewed (see chapter 4.7.3) most herds come from South Tajikistan to graze on the land of forest administration. There are (old) contracts between the former collective farms and forest administration in which the payment of pastures is regulated. In theory herding on the whole 13’624 ha of forest administration Faizabad is forbidden. As figures on the repartition of different land uses (see figure 28) and official testimonies show, half of the territory is rented, partly to other districts for pasture use.

As far as degradation phenomena are concerned, low to moderate degrees prevail in the average (see figure 30). Where strong or extreme degradation occurs (for loss of soil life) only six from ten sampling sites turned out to be affected by this process. The 2007-2008 drought mentioned by many land users is reflected in high extents of compaction and aridification.

On the long-term, remote areas have become less intensively used. This has to do with the many former villages on the area of today's forest administration that used to keep livestock and use parts of the surrounding land as cropland or as orchards. These villages were abandoned between the beginning and the middle of the 20th century which meant a pressure-decrease in these areas. In addition, since the breakdown of the Soviet Union, less herds are coming from the South and less animals are grazing on forest administration land, according to this institution. But employees from forest administration mention that the carrying capacity in terms of livestock numbers and the number of herds is lower during droughts (like in 2008) than otherwise. And they think that the change in livestock numbers is only temporary. At the same time the area designated as for herding has slightly decreased as a result of land users renting land for the establishment of orchards.

Due to their less intensive use, the conservation state of the seminomadic areas is generally good, despite the degradation processes already described. Conservation measures were difficult to make out in the field and could only be proved for one sampling site by asking a herder. But from interviews with experts (forest administration, village elders and chiefs) it became clear that much was done in the past for the conservation of the forest administration area.

A village chief explains how in the second half of the 20th century forest administration was precisely built up as an institution for the rehabilitation of severely degraded areas (by herding): Little villages (abandoned in the past) were built up together with roads and schools for the workers who started building terraces and planting nut trees on them. Some of these measures are still visible, whereas in well accessible herding areas trees and terraces have been damaged. But even here the number of livestock grazing and the periods of grazing are lower and the cycles of rotation are longer than on daily pastures. Together with the well-conserved soils and vegetation-cover (including trees) grassland management contributes to the best ecological performance compared with the other pasture-types (see figure 31).

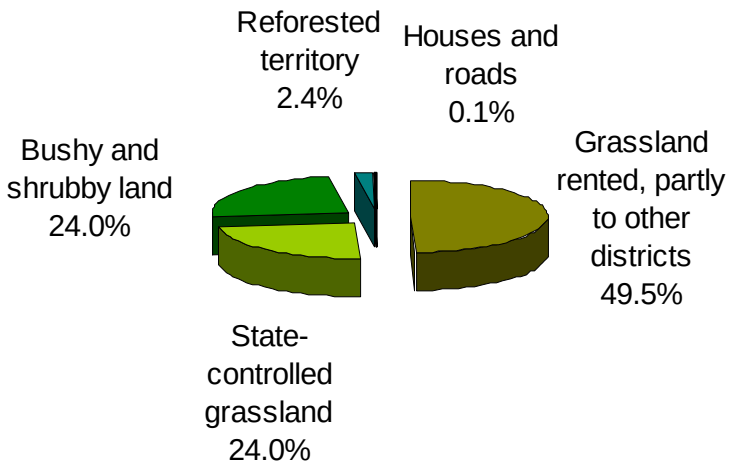

Figure 28: Land use on forest administration land (Forest administration of Faizabad 2008).

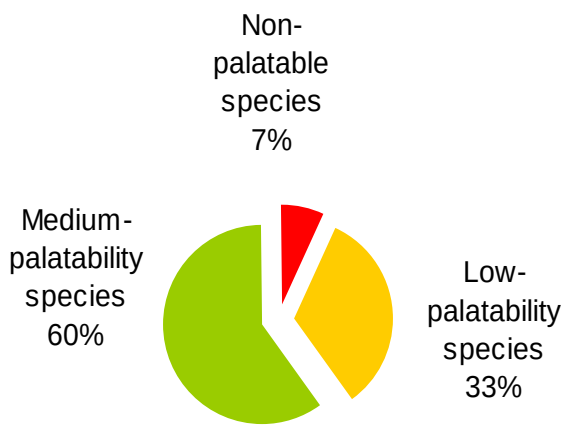

Figure 29: Palatability of vegetation, for seminomadic areas.

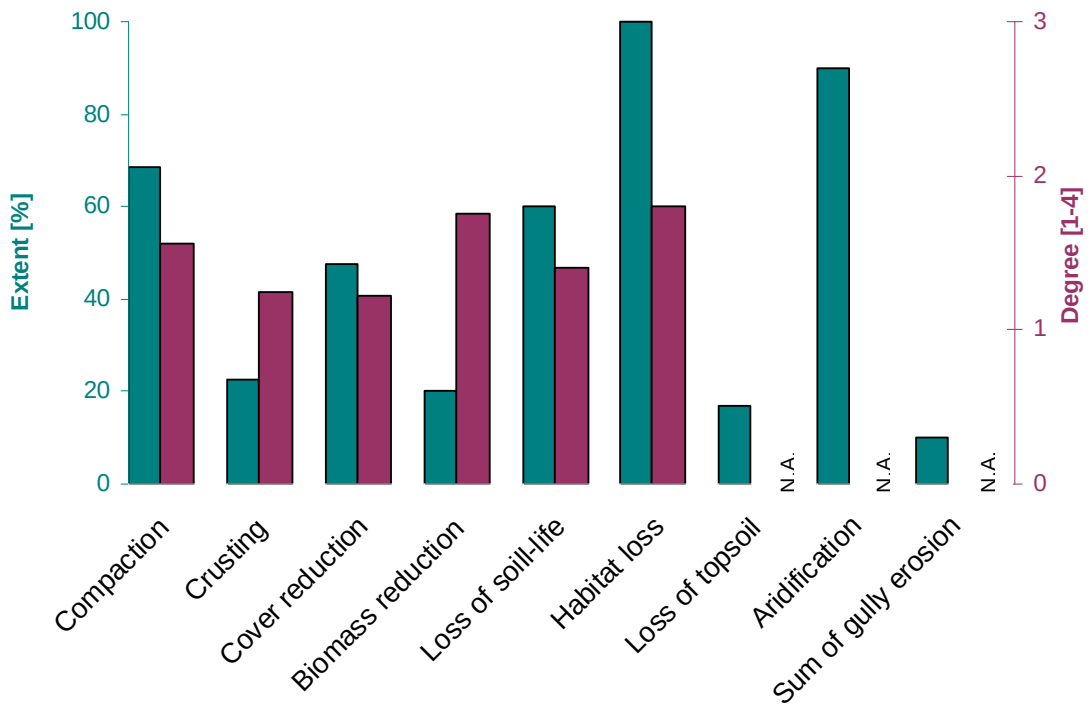

Figure 30: Degree and extent of different degradation indicators, for seminomadic areas.

Productive ESS (production, water quantity/quality) are little affected by degradation according to field assessments and moderately affected as far as the calculated sum of contributing degradation indicators is concerned. The conservation impact for the same ESS assessed in the field, based on high impacts of vegetation quality, is superior to the conservation impact calculated according to table 8, based on low impacts of soil and vegetation indicators. For soil-related ESS (soil structure, organic matter) calculations and field assessments confirm high positive impacts of the comparatively good conservation state of soils. For regulative functions (flood regulation and drought resistance) both methods suggest moderate degradation and conservation impacts. Results of vegetation-related ESS are complex: While microclimate is very positively affected by the high tree and shrub proportion, for biodiversity neither strong positive nor negative impacts are verified.

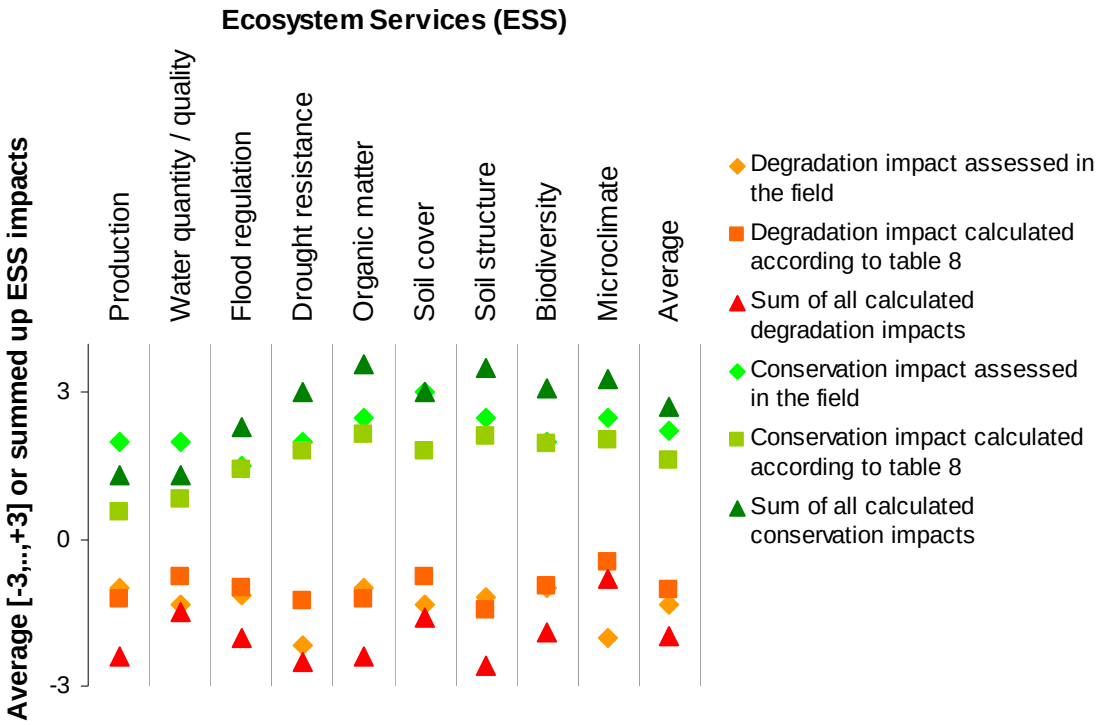

Figure 31: Positive and negative impacts on ESS, for seminomadic areas.

4.3 Cut and carry areas

Land use designated primarily for fodder-production consists of around one fourth of the totally assessed area. Both haymaking and areas additionally dedicated to fruit-production constitute a high obstacle for grazing use. Land users do not send their animals to these places, because they are conscious of the negative impact of grazing on vegetation, especially trees. Thus conservation measures take an important place in the discussion of these LUS.

A very obvious characteristic is the prevalence of certain good fodder species, such as representatives of *Medicago sp.,* in the case of fruit and haymaking areas especially alfalfa (*Medicago sativa*) (see also figure 32).

4.3.1 Haymaking areas

This LUS is often found in rather steep areas and its main attributes are high cover values with grasses and palatable species predominating (see figure 32) and a high biodiversity. Their appearance is similar to seminomadic pastures, especially in the case of selective use. This means that hay is only made if the proportion of forbs, especially thorny plants, is low enough and if the areas are accessible on forest roads (for transport). The threshold of use depends much on the size and quality of the haymaking areas and varies between the villages. Haymaking areas are considered as cut and carry system, even if animals are in most cases present only in late summer, when the actual pasture areas are depleted.

The state of degradation is comparable with the former LUS. Mowing of vegetation (often done by scythe) is the cause of biomass reduction. Specialists consider it to be a problem if grass is cut too early because it creates lack of reproduction. This is why farmers' associations often do not allow haymaking before the end of June. With its few trees habitats are stronger reduced than in seminomadic areas. Erosion by water is even a smaller problem than in seminomadic areas (no gully-erosion), as can be seen in figure 33.

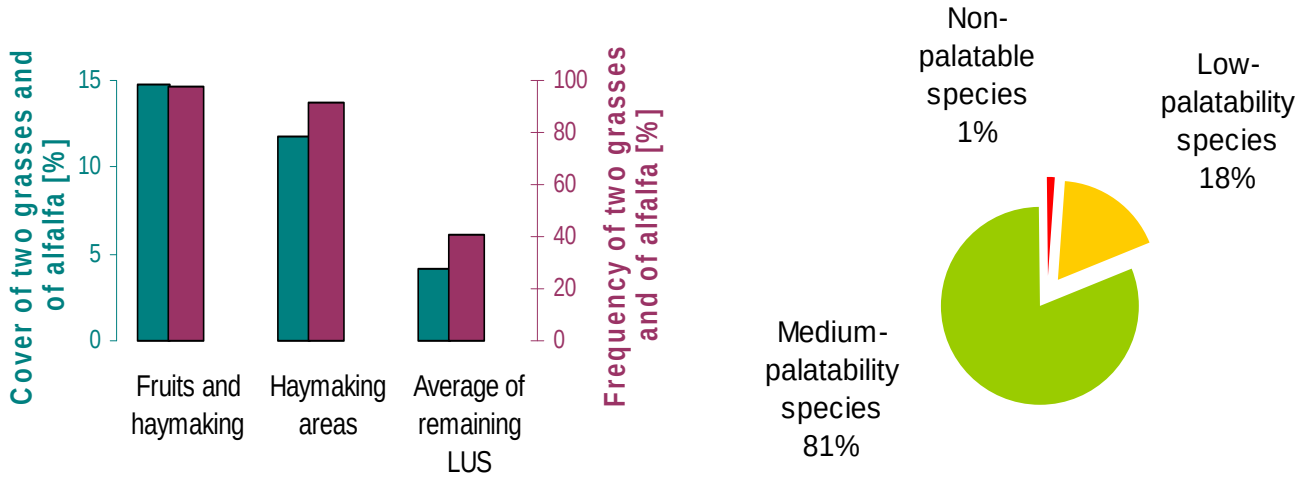

Figure 32: Frequency and cover of *Hordeum bulbosum*, *Medicago sp.* and *"Rafida Kahag" (left) and* palatability of vegetation, for haymaking areas (right).

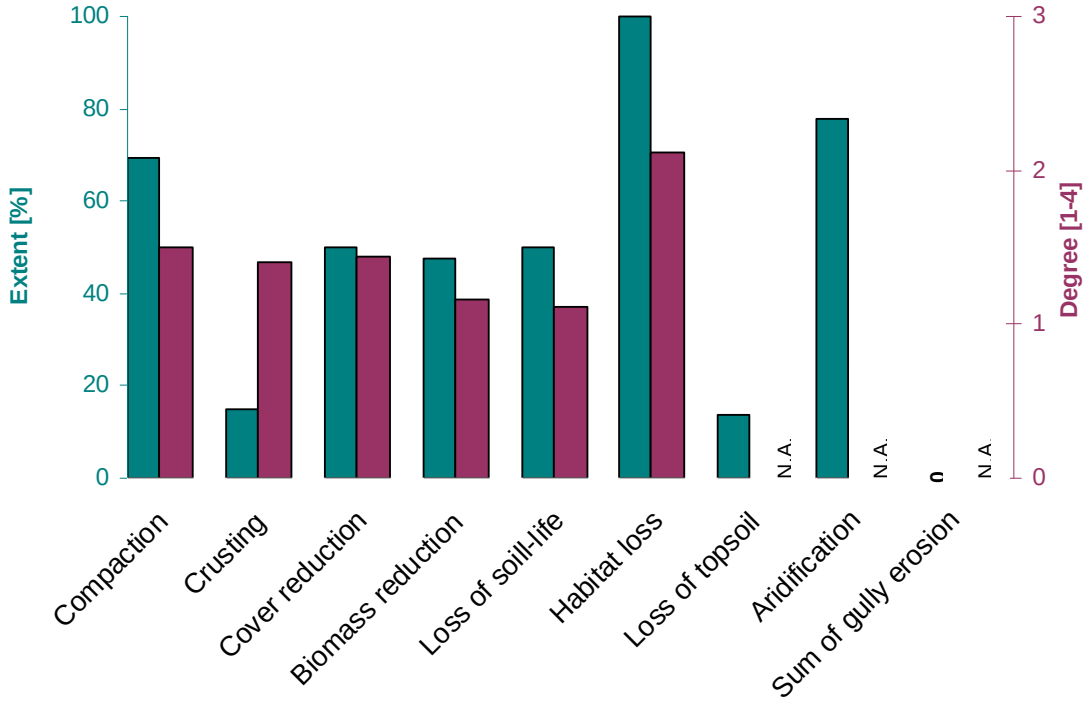

Figure 33: Degree and extent of different degradation indicators, for haymaking areas.

As far as dynamics are concerned minor changes in degradation can be observed. With the prices of fertilisers increasing they are no longer used. Fertility constantly declines and vegetation is becoming more and more natural. Biodiversity is maintained thanks to the late cutting of vegetation, usually from the end of June onward. Besides, many haymaking areas are more selectively used than in the past. Especially remote areas require expensive transport by truck or at least by car – on forest roads that have not been maintained for a long time. However, many people rely on donkeys to transport hay (see figure 34). As to spatial dynamics, during Soviet Union sectors of haymaking were defined that are respected till the present. There has even been a slight spatial increase with more people being able to afford to lease areas that used to be pastures.

Figure 34: Transport by donkey (left) and by truck (right).

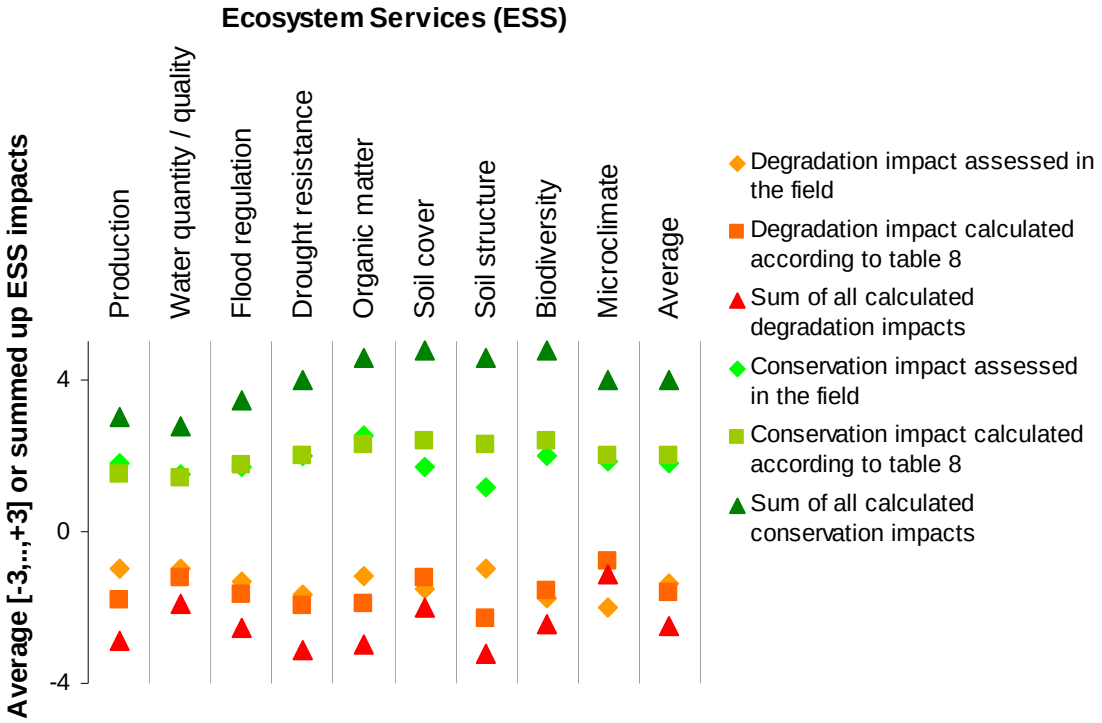

Figure 35: Positive and negative impacts on ESS, for haymaking areas.

The measures of conservation taken are mostly grassland management methods: As discussed, this LUS mostly implies very limited grazing periods, which are judged to be moderately efficient. The control of livestock access, which is sometimes successful (recently maintained fences) and sometimes less (little children given the task of chasing away animals) helps to improve efficiency. This strict grassland management is reflected in net positive values for all ESS (see figure 35).

The impacts of both conservation and degradation on water-related ESS (water quantity/quality and flood regulation) are judged as low to moderate. The ESS biodiversity and microclimate are positively influenced by the good state of vegetation. The degradation impact on these two ESS is more negatively judged in the field than by field-calculations. It seems that production itself is neither strongly affected by degradation nor by conservation. Organic matter as a soil quality indicator is positively affected by conservation whereas the magnitude of the degradation impact on organic matter and soil structure is unclear, as far as observations and calculations are concerned.

4.3.2 Fruits and haymaking

Orchards are very green spots in the landscape that are characterised by high cover values with many good fodder plants (see figure 36). They generally appear as areas with high cover and are often situated in rather flat areas. The main uses are the production of fruits – from apricots, apples, quinces, peaches, mulberries, sea buckthorns to walnuts – together with fodder-production. It is the only pure cut and carry system, since grazing is generally strictly forbidden. Often, access is not possible for animals thanks to fencing or other physical barriers.

The degradation degree for important indicators ranges from light to strong. Plant diversity is lower in orchards (28 of 43 assessed plant species) than in haymaking areas (33 species). Figure 37 shows a high degradation extent for all indicators, except for crusting. Compaction with nearly 100% average extent over all considered sampling sites is a matter of dry conditions, combined with recent tilling that contributed to hardening the soil in droughts, according to a specialist. Both degree and extent of biomass reduction are high, because in both cases the indicator is understood as the reduction of standing biomass by haymaking use (like in haymaking areas). Aridification can only be made out for half of the sampling sites in orchards (against ¾ on the average for the other LUS), thanks to high proportions of green vegetation, often alfalfa. Still, orchards are heavily affected by droughts, as can be seen by many dried out grasses that cannot be identified anymore: 68% of total cover is constituted by plants not contained in figure 36, often non-identifiable ones.

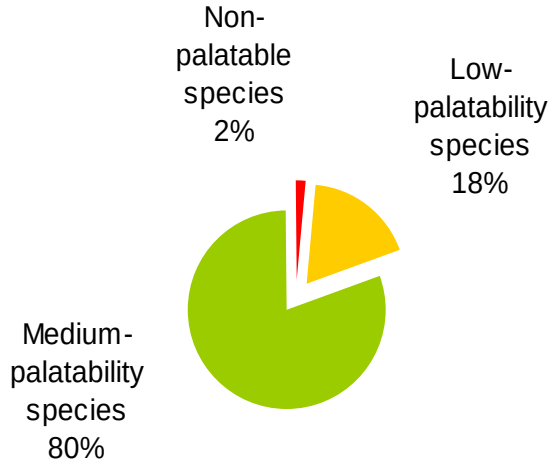

Figure 36: Palatability of vegetation, for fruits and haymaking areas.

A slight decrease in land use intensity can be observed since the end of USSR. The most important change, according to a land use specialist, is the decreased use of fertilisers (phosphates) that shows in reduced biomass. The proportion of thorny plants seems to have decreased in some cases, thanks to physical removal. As far as the spatial extent of this LUS is concerned, there has been a clear benefit of the possibility to lease land as a farmers' association. Even if this possibility already existed in the late USSR it has only become necessary to make use of it in the new economic situation after independence. The surface of orchards has annually more than tripled between 2004 and 2008 and reached 343.83 ha in 2008 (Jamoat 2008) on the territory controlled by villages (from totally 466.72 ha for the whole mapped area).

As seen, the conservation state of this LUS is good. This has to do with a series of conservation measures (see figure 38) often adopted at the same time: Besides planted fruit trees strict grass-land management – in most cases no grazing at all – is a fix constituent of orchards. And in many areas terraces can be found. The measures are generally efficiently implemented by the land users – often land renters. Measures difficult to assess in the field are nutrient management and sowing of fodder species. In many orchards animal dung is applied and, where land users can afford it, fertilisers too. And the dry conditions in 2008 in many cases did not let the sown grasses grow, so that they were invisible.

When looking at the impacts of both degradation and conservation, net positive values for all ESS result (see figure 39), as for haymaking areas. For certain services the positive impact of fruit trees clearly beats the negative impact of reduced standing biomass and compaction, as for example in the case of production or microclimate. In case of water-related ESS (water quantity/quality, flood regulation, drought resistance), calculations and (a bit less) observations suggest a balanced situation. High cover values and often blackish soils deliver net positive effects on biodiversity and organic matter in calculations, whereas in the field the situation was estimated to be more strongly influenced by degradation.

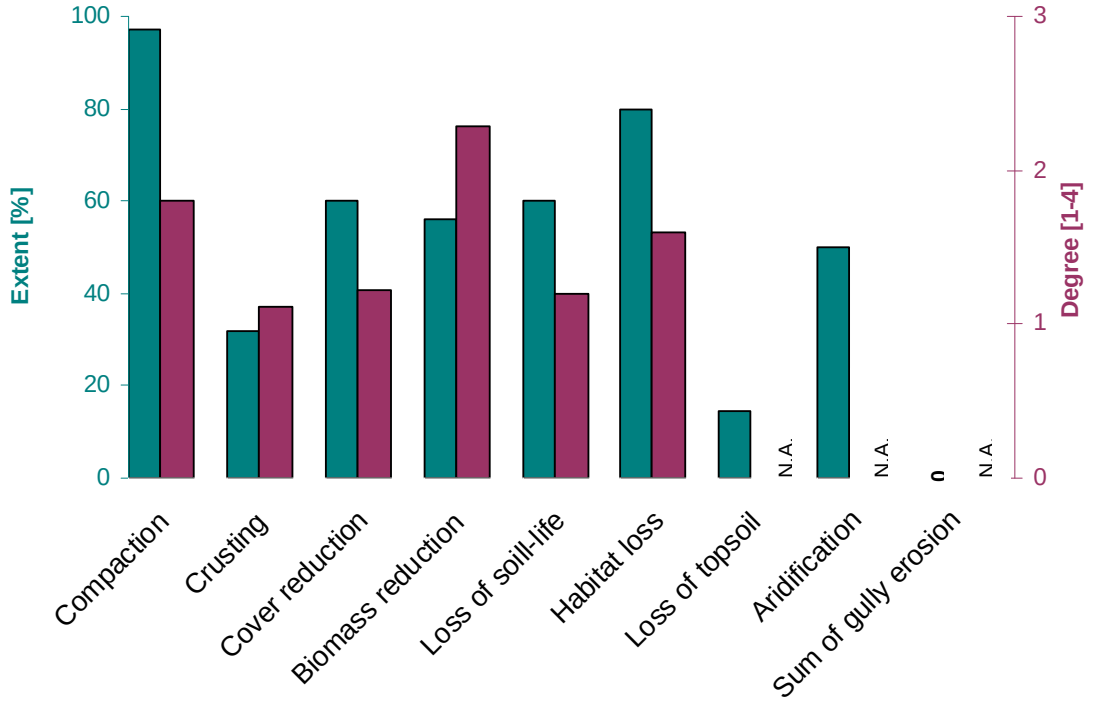

Figure 37: Extent and degree of the dominant degradation indicators in orchards.

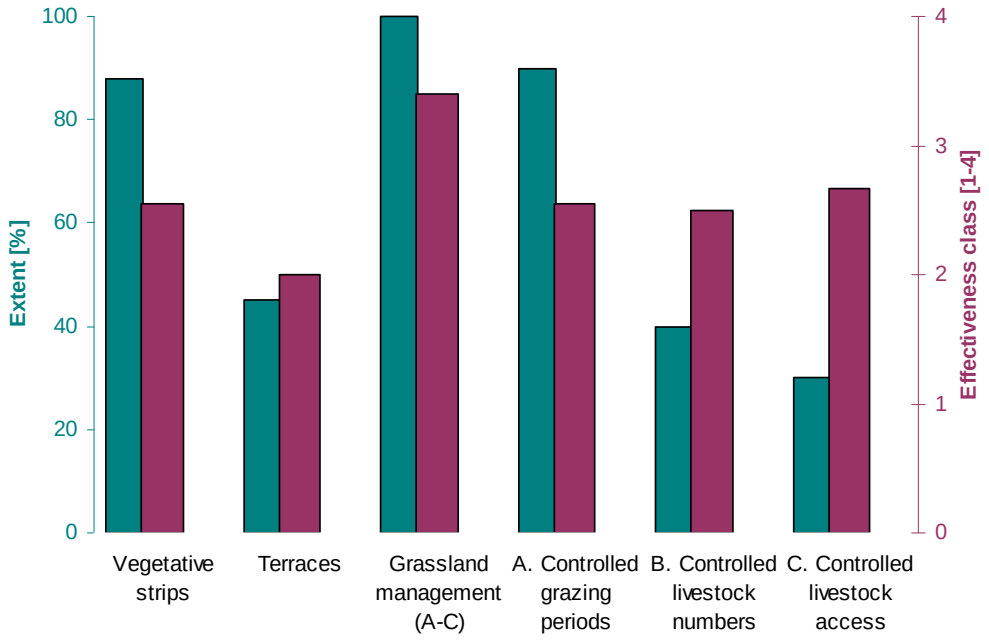

Figure 38: Mix of conservation measures in orchards.

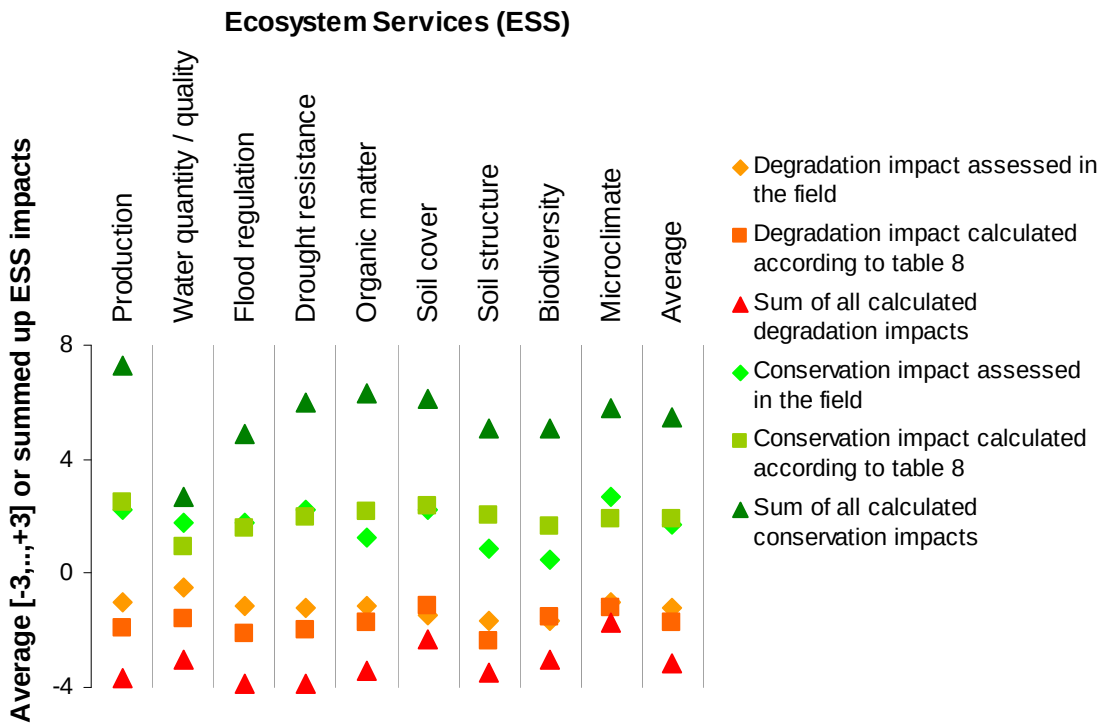

Figure 39: Positive and negative impacts on ESS, for fruit and haymaking areas.

4.4 Mixed uses

Both former cropland and marginal areas can only be used with difficulty: in the first case because of strong degradation and in the second case because of low accessibility (very steep). These areas are used either for haymaking or grazing or for both. The two LUS are subject to regular disturbances. This is shown by a high proportion of forbs from the non-palatable and low-palatability groups, often ruderal species (see figure 40). The combination of such species and a high frequency and cover are typical, not the illustrated species alone.

4.4.1 Former cropland

This LUS is defined by its past use as cropland in the years following independence of Tajikistan. They are now used either for haymaking (6 from 10 sampling sites), as pasture-land or in combination. It must be said that some orchards also used to be cropped. In addition many remote areas used to be within reach of (past) villages and thus used as cropland till the 1950s/1960s. Often they are not recognisable as cropland anymore. This means that former cropland must be recognisable as having been used exclusively as cropland (without trees for fruit-production): by a plough horizon, a plough line or by confirmation through land users. Generally such areas have medium cover values with a low proportion of grasses and a high proportion of forbs (see figure 40).

Figure 41 gives the impression of heavy degradation especially in biological terms. For example, all sampling sites show an at least moderate habitat loss. The varying present use as haymaking or pasture areas is reflected in a high standard deviation many considered indicators: The average standard deviation is of 32%, which is the highest value of all LUS (see figure 42). Generally physical degradation of soils and reduction of vegetation cover and biomass have a higher degradation degree and extent than water erosion indicators (loss of topsoil, gully erosion), as for the also not so steep fruit and haymaking areas.

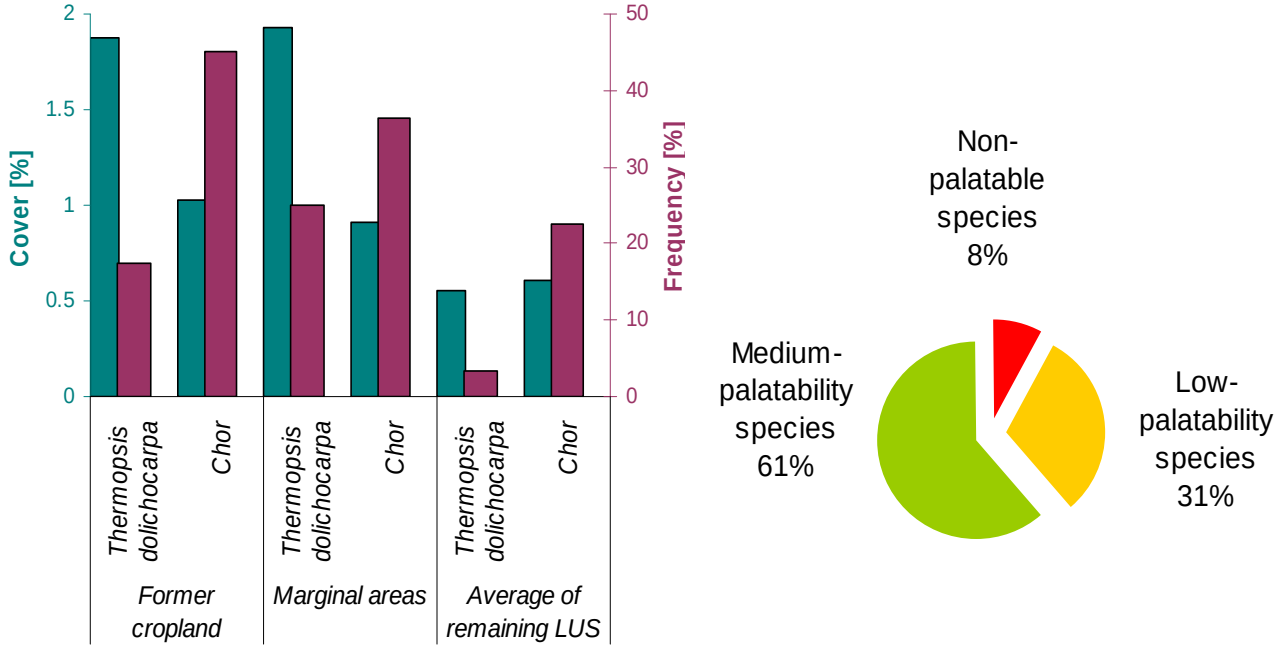

Figure 40: Cover and frequency of ruderal plants (left) and palatability of vegetation, for former cropland (right).

The dynamics in particular are interesting when looking at this LUS. These areas were used for crop-production during civil war. As they are not irrigated, in most cases harvests were very modest. This led to giving up crop-production, once the economic situation was better again. The land use committee on the district level wants to convert these areas into cut and carry systems and not allow grazing anymore, as a conservation measure. And land users are asked to sow esparset or alfalfa. The only land user interviewed who implemented this strategy is the head of the first farmers' association in one of the villages and a wealthy man. He also invested several thousands of dollars to convert a part of these croplands into vineyards. Both sowing alfalfa and planting vines have proved difficult in terms of returns: many vines have not survived the hard winter 2007/2008 and the remaining ones were suffering from drought in summer 2008.

There is a general decrease in land use intensity, which is not always visible in less degradation. According to an expert, vegetation has quite well recovered in terms of quantity (biomass, cover) since the cropping stopped, whereas the quality of vegetation (proportion of thorny plants and forbs) and soils (crusting, compaction) has been severely impoverished in the last ten years.

As shown, the situation of degradation is highly variable, due to variable land use: For instance, the conservation measure of grazing after haymaking is found on half of the sampling sites. And, as for (past) tree-planting, efficiency is only low to moderate. This is shown in the effect on ESS, which is much higher for degradation than for conservation (see figure 43). Net negative values for all ESS result, if degradation and conservation impacts are added. Impacts on vegetation-related ESS (soil cover, microclimate) are positive. Production and regulative (drought-resistance, flood regulation) such as soil-related functions (organic matter, soil structure) are either heavily affected by degradation or conservation measures are not sufficient for net positive effects. For biodiversity the estimations in the field (high degradation and low conservation impact) are not reflected by calculations (low degradation and high conservation impact).

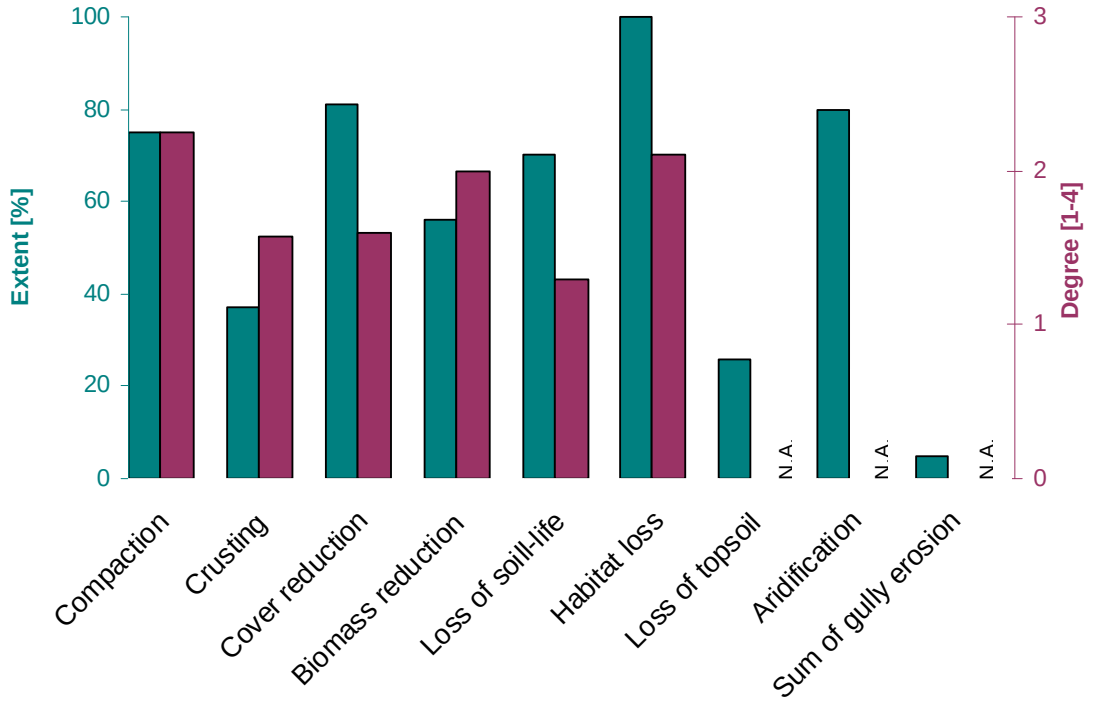

Figure 41: Extent and degree of the dominant degradation indicators on former cropland.

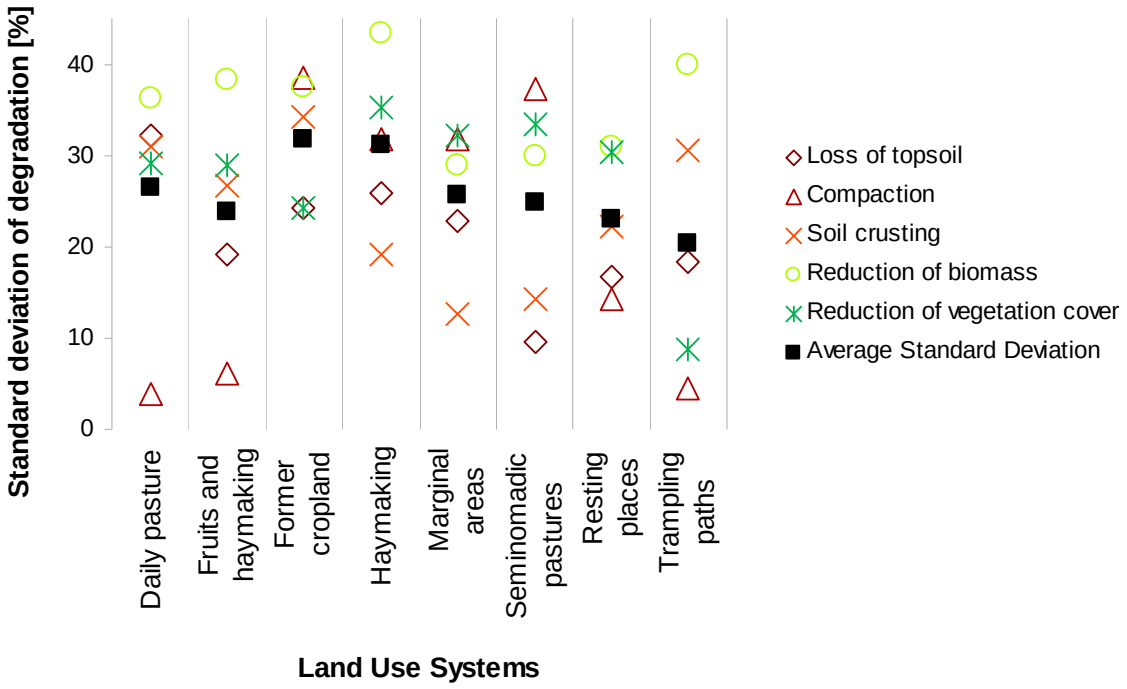

Figure 42: Standard deviation for the extent of different degradation indicators [%].

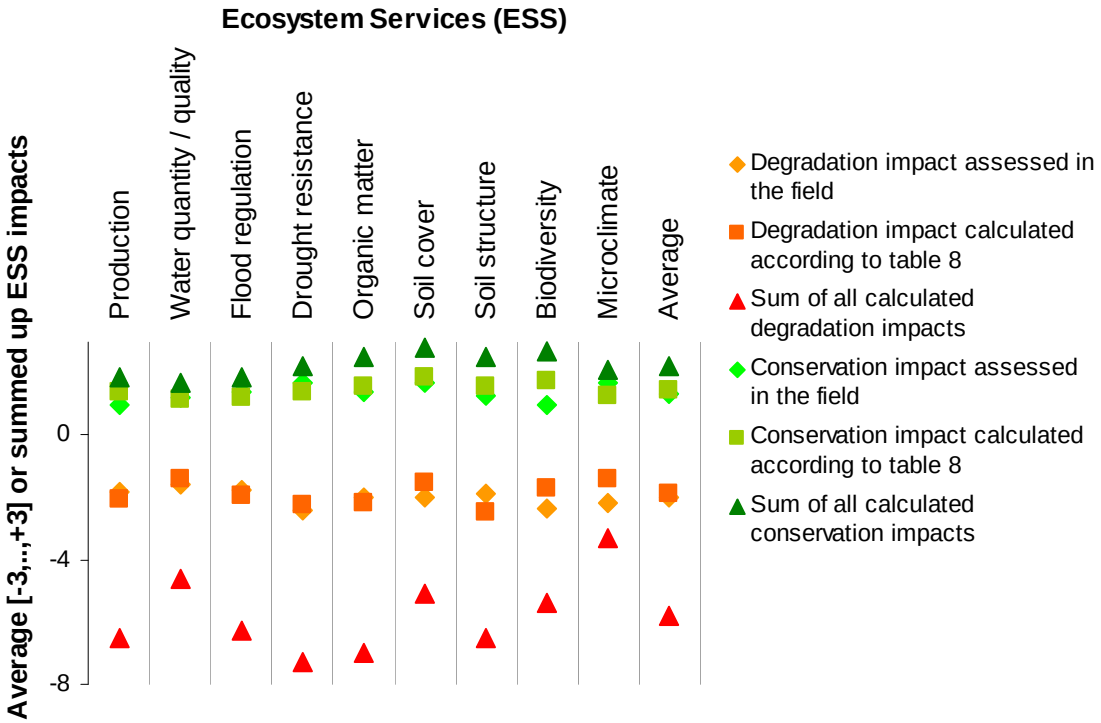

Figure 43: Positive and negative impacts on ESS, for former cropland.

4.4.2 Marginal areas

Such areas usually accompany rivers on their way to the plains as more or less wide, steep stripes. With their steepness and a high proportion of trees, shrubs and non-palatable species (see figure 44) they are not adapted to intensive use. Marginal areas surrounded by haymaking areas are used for fodder-production, the ones in the middle of a pasture-area are grazed. At the border between cut and carry and pasture areas there may be a combination of uses. Pasture-use is concentrated on areas next to paths where animals daily pass and haymaking on less steep areas not affected by bush encroachment.

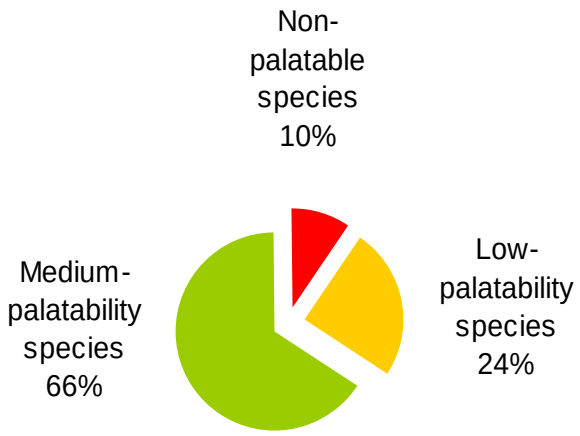

Figure 44: Palatability of vegetation, for marginal areas.

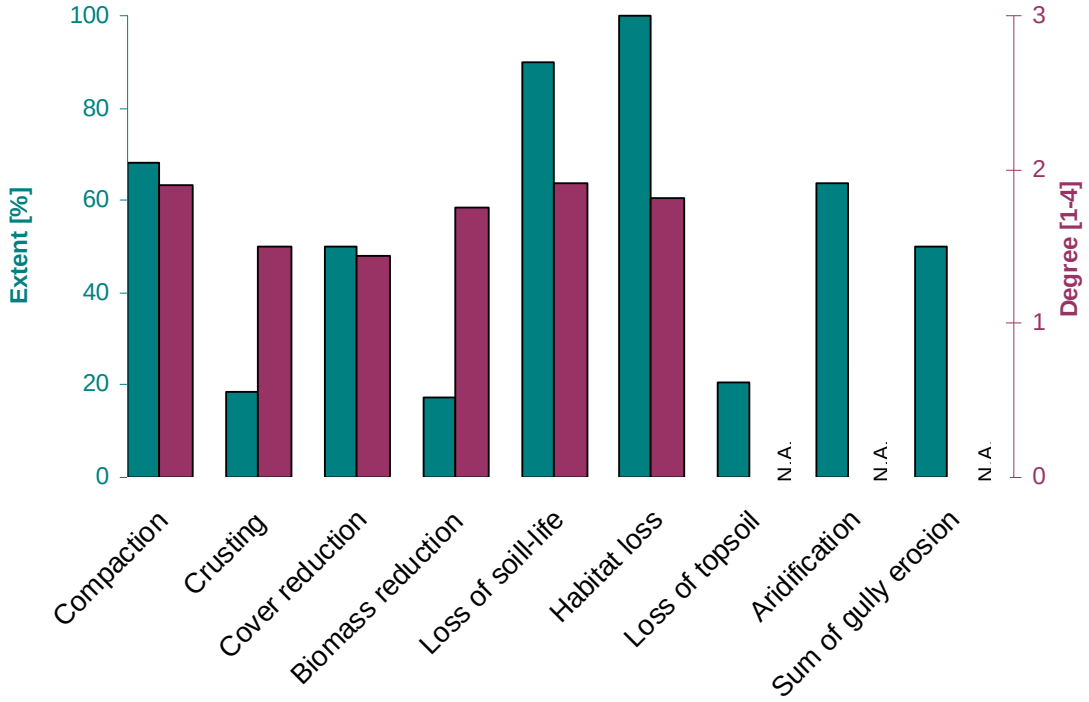

Figure 45: Extent and degree of the dominant degradation indicators in marginal areas.

Marginal areas are especially prone to cover reduction (see figure 45), with a relatively high density of small animal paths, especially in steep areas. Goats and sheep have access to very steep areas. By their trampling they can cause landslides in moist areas, for example next to streams (see figure 46). Besides trampling, gully erosion and the loss of soil-life are common degradation phenomena in these steep areas. Other degradation indicators show comparatively low to moderate extents and degrees. The mostly moderate loss of habitats gives the impression that trees and shrubs are missing. In reality trees and shrubs were often found outside the assessed transects that were used for the calculation of the indicator.

In interviews with land users no major land use intensity changes could be identified. But, especially in pasture areas where trees were cut down during and after civil war, the formation of gullies has increased, according to a land use specialist. Once gullies reach a certain depth and width they will also be part of this LUS, contributing to an eventual future increase in the area of these.

At least one conservation measure of those presented in table 6 is found on 7 from 11 sampling sites, mostly a grassland management measure. In some haymaking areas two measures are combined (mostly controlled grazing periods and controlled livestock numbers), whereby efficiency is higher than where only one measure is taken.

With these conservation measures, low accessibility and mostly a high proportion of trees ESS values for marginal areas are positive (see figure 47). Only productive and water-related functions (production, water quantity/quality, flood regulation) are in the balance of the impacts of compaction and other degradation indicators on the one hand and of blackish soils amongst other positive factors on the other hand. According to field assessments and calculations, especially for ESS related with soil (soil structure, organic matter) and vegetation (biodiversity, soil cover, drought resistance), the positive impact of a good conservation state outreaches the impact of different degradation indicators. In case of microclimate the two methodological approaches disagree: Whereas calculations suggest a strong positive impact of (natural) trees on this ESS, field assessments weighted cover reduction more strongly.

Figure 46: Moist, steep areas close to rivers with animals regularly passing are prone to landslides.

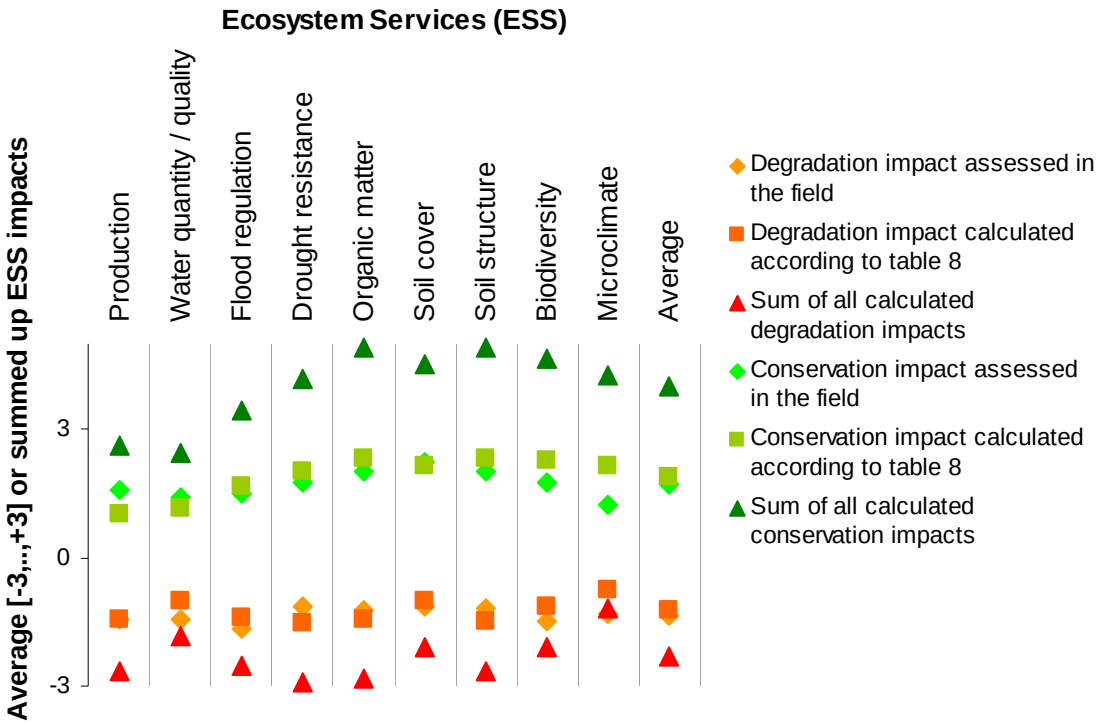

Figure 47: Positive and negative impacts on ESS, for marginal areas.

4.5 Conserving and degrading LUS

As a summary of the above chapters the state of resources and of ESS is analysed in a comparison of the LUS.

If the average values of both the extent and the degree of state indicators are compared between the LUS (see figure 48), the following conclusions can be made:

- LUS with low slope and high cover values (fruit and haymaking and resting places) on the average are less prone to degradation by water (gully and topsoil erosion) than LUS with high slope and low cover values;
- Selectively used LUS (seminomadic, haymaking and marginal areas) show a lower degradation extent and degree than areas with past tilling (fruit and haymaking areas and former cropland) and LUS with intensive trampling (trampling paths, daily pastures and resting places);
- The same distribution of LUS is true for the degradation of vegetation in quantity (cover, biomass), this time with the main degradation causes of droughts, grazing (large herds) for pasture-areas and haymaking for cut and carry systems;
- Indicators of animal life (loss of soil life and loss of habitats) indicate strong degradation for areas of regular trampling (trampling paths, daily pastures and resting places) and for marginal areas, where high vegetation cover might impede to detect soil-life and where plant diversity is maximal.

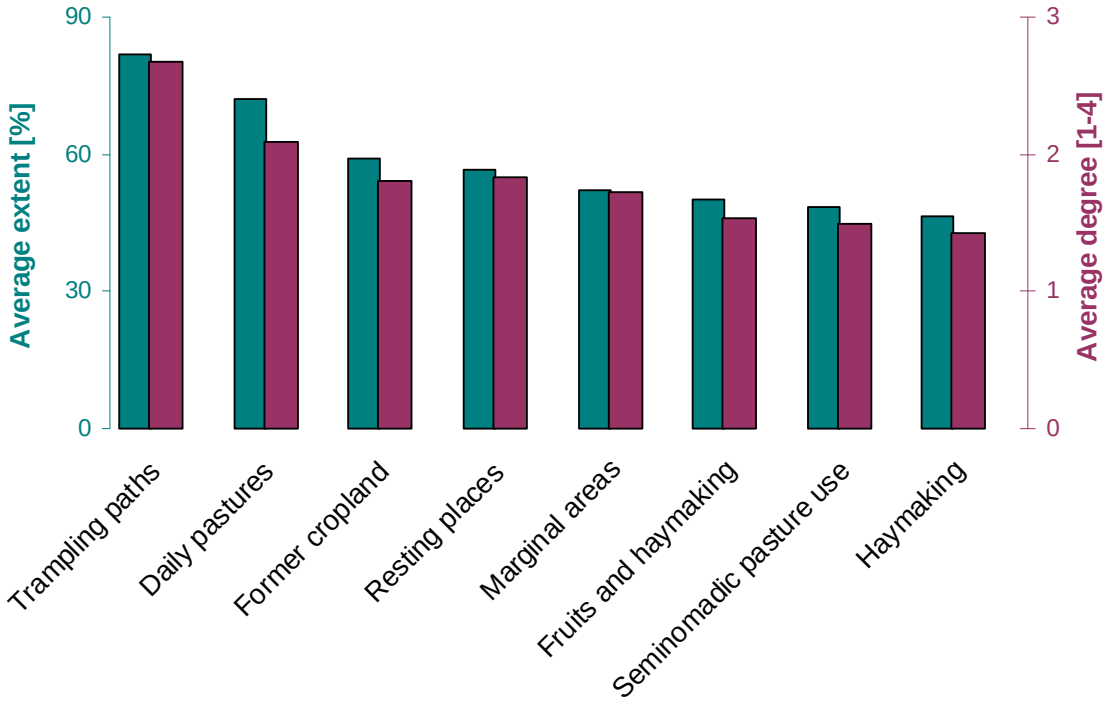

Figure 48: Average degradation for the following indicators: compaction, crusting, cover reduction, biomass reduction, loss of soil life, loss of habitats, loss of topsoil, gully erosion and aridification.

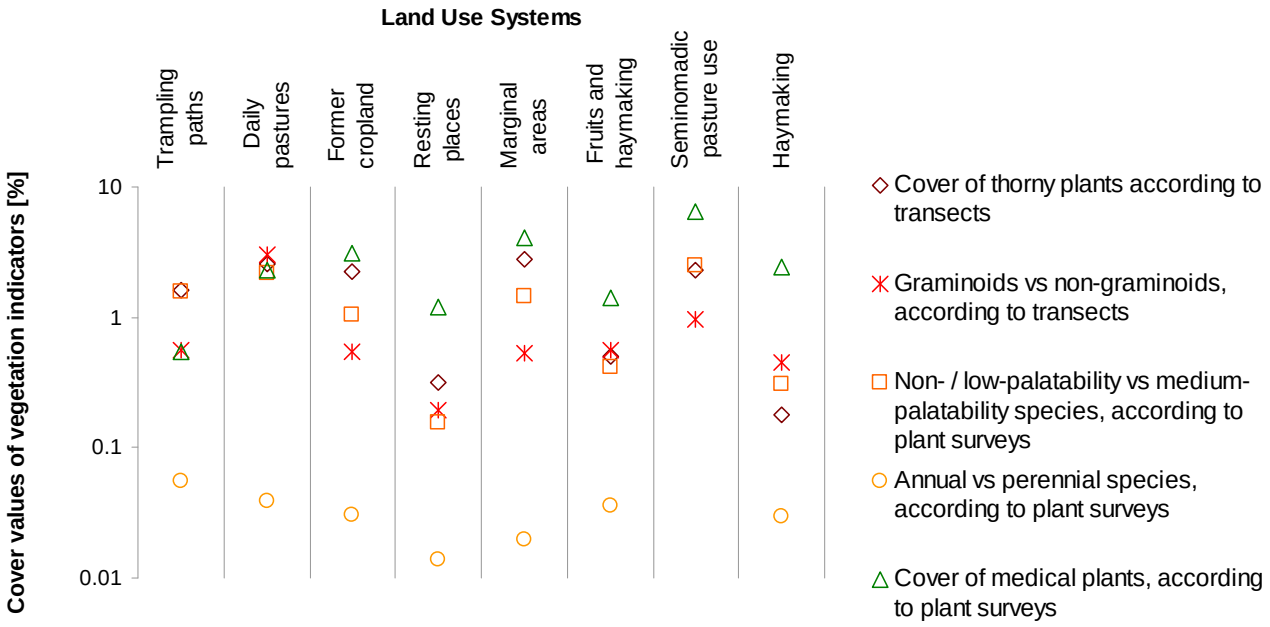

Figure 49: Important indicators of vegetation quality derived from cover values.

It is possible to conclude that areas regularly used by big herds and areas with an inappropriate use (depletion of soils through cropping or grazing on steep slopes) are hot spots of degradation. The herder's perspective though is more strongly concentrated on vegetation quality (see figure 49) that can be summarised as follows:

- The proportion of thorny plants in pasture areas (except for resting places) and areas of mixed use Is high, whereas cut and carry systems are not strongly affected;
- Only for cut and carry systems and resting places cover and frequency values of plants from the medium palatability group are superior to those of plants from the two other palatability groups (description of palatability groups in chapter 3.3.1);
- The proportion of graminoids in terms of cover is very low on daily pastures, low on seminomadic pastures, very high on resting places and quite high for the remaining LUS;
- Among the assessed plants, the proportion of perennial ones is generally very high in midsummer, when the assessments are made. There are rather high percentages of annuals on trampling paths and daily pastures, contrasting with very low values on seminomadic pastures and low values in marginal areas.
- The cover values of medical plants are very high on seminomadic and marginal areas and high on former cropland, but very low on the low-cover trampling paths.

The above enlistment shows that generally the hot defined above are also valid in terms of vegetation quality. But even vegetation highly reduced in quantity can be valuable from the point of view of quality: Resting places with their very high grass-proportion and a low proportion of thorny plants are interesting pastures. And seminomadic pastures and marginal areas with a high proportion of medical plants that are collected by villagers show other uses of vegetation than grazing; in addition, with their high proportion of perennial species they appear as especially stable ecosystems. Ecosystems are now discussed in terms of ESS.

Productive and ecological functions are addressed separately in figure 43, with the following conclusions:

- The observed values do not permit to split up ecological and productive functions, except for marginal areas which perform better in ecological than in productive terms and for fruits and haymaking areas, where the opposite is true;
- Both types of ESS are judged to be more balanced in calculations than in field assessments. Agreement on ecological services is higher than on productive functions. Ecological ESS are judged by both methods to have lower values for trampling paths and daily pastures and higher values for cut and carry systems;
- The sum of calculated ESS identifies pasture-areas and former cropland as less conserved areas and cut and carry and marginal areas as more conserved LUS. It makes clear that ecological functions are better provided by all LUS than productive ones and that this difference increases from the less to the more conserved areas: Especially marginal areas perform much better in ecological than in productive terms, whereas trampling paths have a generally bad performance.

The contrasts are better represented in figure 44: The only LUS with net positive values by all three methods (field assessment, calculation according to table 8 and calculated sum) are the cut and carry areas (haymaking areas and orchards). For trampling paths, daily pastures and former cropland negative values result and the other LUS are more balanced.

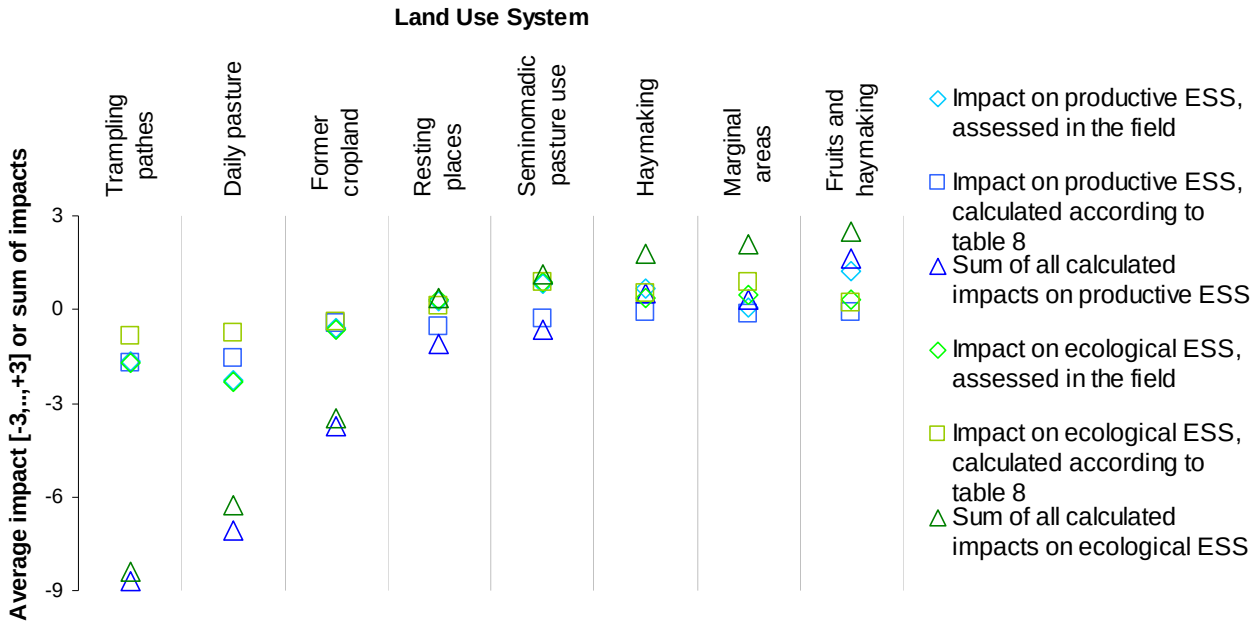

Figure 50: Ecological and productive ESS.

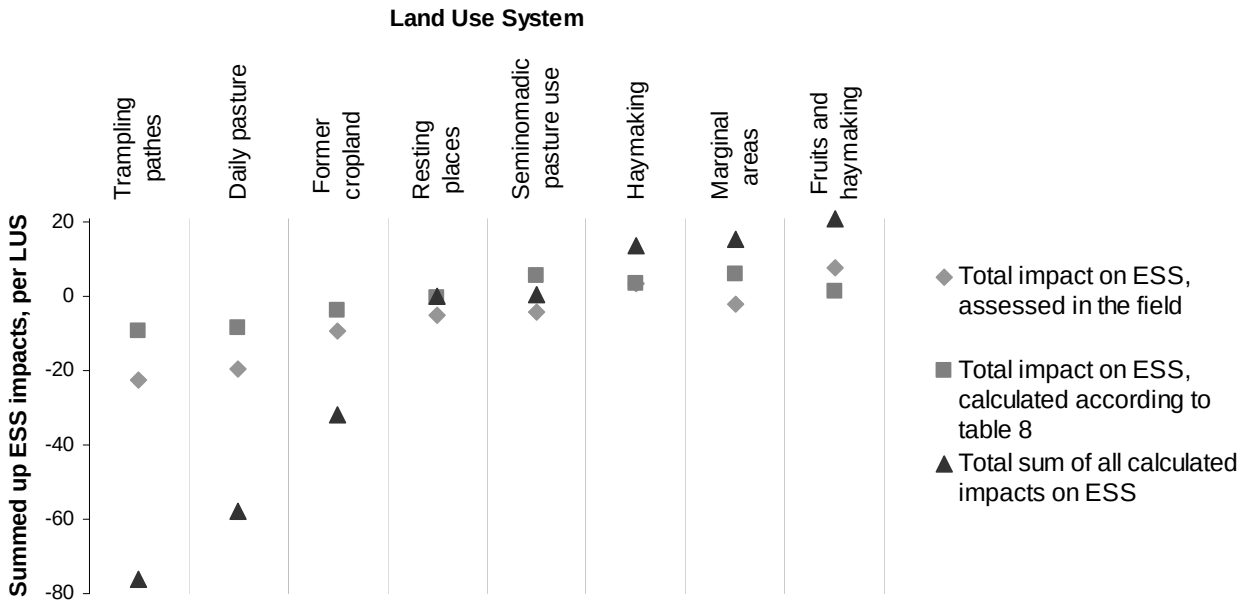

Figure 51: Aggregation of all conservation and degradation impacts on ESS.

4.6 Selected case studies

An overview of the approximate case study areas is given in figure 52. The complete questionnaires are contained on a CD (see appendices).

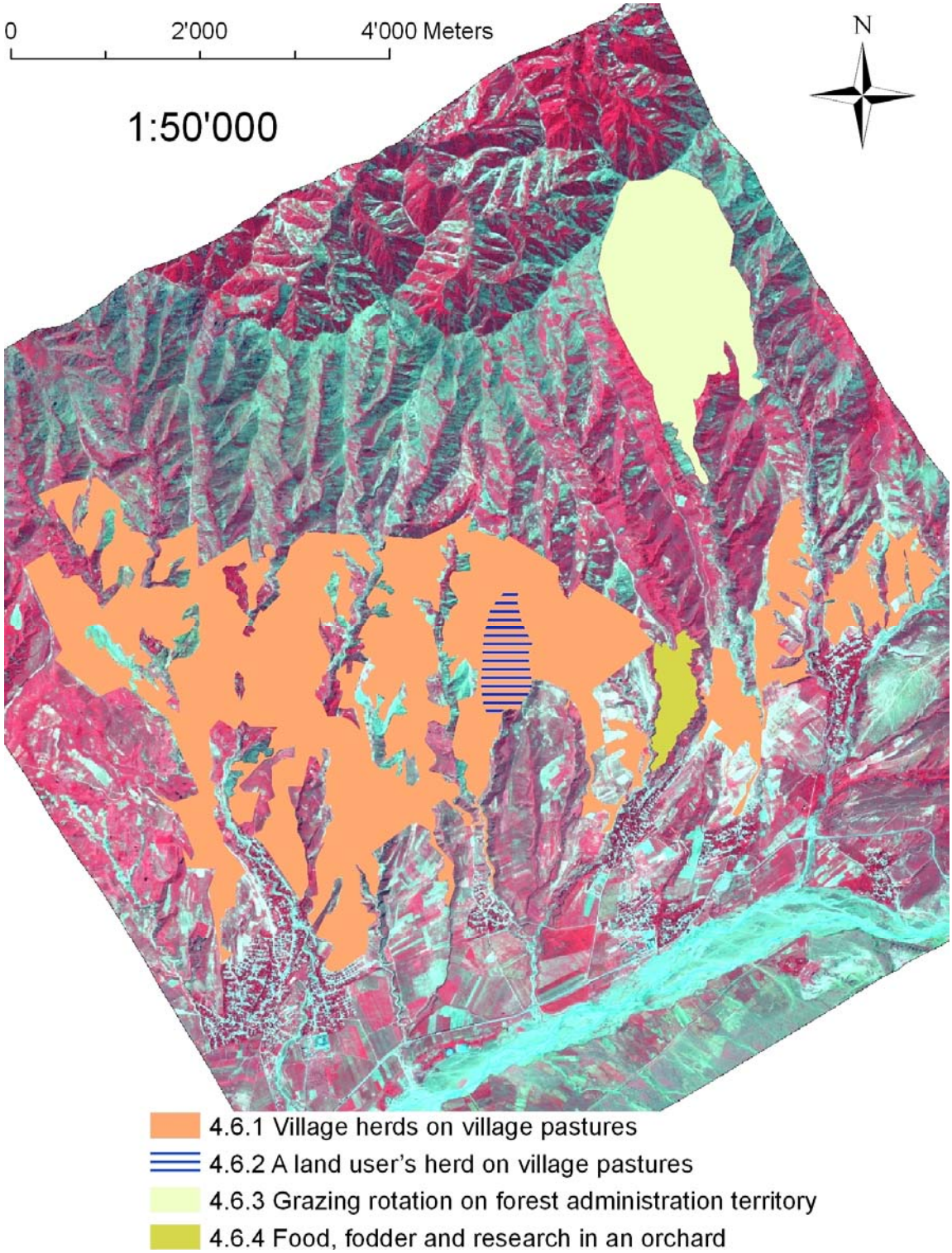

Figure 52: The case study areas are listed according to the chapters 4.6.1 to 4.6.4.

The four case studies listed on the map above will be shortly presented with regard to the applied SLM technologies and approaches. In chapter 4.7 the following aspects of conservation will be compared in synthesis:

- The motivation to implement conservation measures, that is, seeing if land users act mainly to improve productive or also ecological functions;
- The success-factors of conservation and the reasons for failure;
- The different perspectives on conservation: by land users on the one hand and by land administration on the other hand.

4.6.1 Village herds on village pastures

In the WOCAT questionnaires the herding technology is described as *"Daily grazing of village-herds"* and the approach as *"Common village herding"*. It is difficult to say when collective herding first emerged. A land user says that during Soviet Union there were village herds with an assigned herder or an alternation of herders and, correspondingly, wealthy people had their own hamlet with a paid herder. During civil war only a few rich villagers kept animals. At the beginning of the 21st century collective herding re-emerged.

This case study essentially talks about the following LUS: in the first place daily pastures are used by this herding system with trampling paths as access routes. Besides, resting places are used by the village herds and the small animals (goats, sheep) are capable of passing marginal areas. Part of the former cropland is used by village herds, too. Towards the end of summer nearly all accessible areas are used by the herds, except for orchards. This means that the area of common herding is difficult to delimitate and is in the range of 10 – 20 km^2.

The grazing zone is situated between 1400 and 1700 m. Rotation begins between the beginning of March and April on the lower pastures. First the small animals are grazed that are supposed to better cope with slippery conditions. After two weeks the cows are led to the pastures. In some villages they are first grazed separately from the smaller animals, to get them accustomed to each other. At the beginning of summer the higher pastures are used. Towards autumn the animals graze in haymaking areas and next to the villages, sometimes on cropland, feeding on crop residues. The end of grazing season is between the end of October and the beginning of December, when the first snow falls.

The herders are advised to change place every 1-3 days, but in some cases they stay in one place for a longer time. The animals are gathered at a point close to the exit of the village a little after dawn and then brought to the pastures. At noontime they will be lead to a shady place close to a stream, if possible. The same places will be visited at least three times per season. In most villages the start of grazing and rotation are fixed by land use committees in the villages. The main decision criteria mentioned are soil moisture (soil should not be slippery anymore for the security of livestock), a minimal height of grass and warm temperatures (animal health). The committees decide in cooperation with different institutions on the district level: especially the land use committee and the ecology commission which also give ideas on the implementation of SLM. A teacher and member from the local land use committee says that a lot is said about SLM, but little is effectively done. Herding often remains a matter of families and villagers.

Children and adults are taught by the elders, the parents and the village land use committee how rotation works: not to stay at one place longer than three days, not to chase the animals which otherwise lose energy unnecessarily and not to lose animals. Children not obeying are punished. In case of lost animals different approaches exist. Mostly the family of the herder who was responsible for the herd on the respective day reaches an agreement with the tenant's family. The village committee or elders can also arbitrate.

The described herding system is easy and little labour-intensive, because children are the main workforce. It is difficult to find at least one adult herder each day to be the main person responsible of the big herd (between 200-600 animals). This collective system requires the participation of all households with families: for instance in the village of Karsang, each family has to send monthly one child for herding or pay if it has no workforce. In addition, always at least one adult has to accompany the herd. Children of big families thus only rarely miss school whereas those from small families miss more frequently. The final objective is to nourish animals maximally so they need a minimum of costly hay and concentrated feed (in financial respectively in terms of labour). If cows give 1.5 - 3 litres of milk this is already an average value and thus accepted as normal. But a land user kept his cow at home towards the end of summer. It had stopped giving milk, because of sparse and dry vegetation on the pastures.

The costs of this form of herding are low: animals must be fed through wintertime, if possible, with concentrated feeds. They must be given salt regularly. If an animal is sick, medicine and sometimes the veterinary have to be paid or the animal is killed. Labour costs in most cases are zero, but each household is asked to regularly send a family member for herding. In most villages the households pay taxes per animal, calculated on the basis of livestock numbers and pasture area.

Figure 53: Gullies on village pastures (left) and *"devils"* (local name for goats) eating trees (right).

Some land users say that the pastures used this way are heavily suffering from overuse (livestock units) on the one hand and are vulnerable to temperature increase and droughts on the other hand. They are in a heavily degraded state. Erosion by water, including gullies and offsite-damages, is a common phenomenon, especially in low cover areas (see figure 53); wind-erosion is a problem, according to land users. It can be summarised that this grazing system is not functioning well: pastures under such intensive grazing pressure are little productive.

4.6.2 A land user's herd on village pastures

In this case study the focus is on *"Reduced livestock numbers"*, based on a *"Family-based daily herding"*. The pastures used consist of resting places and seminomadic pastures, but also of marginal areas and daily pastures. After renting land for the implementation of an orchard, building a hut and starting to cultivate a garden, the land user bought a herd. This means that for him breakdown of USSR marks the beginning of his *"Self-made man"* approach.

Around 50 goats are brought to the pastures early in the morning and back to their stable from 9 a.m. to 5 p.m. (see figure 54). After this, they will be accompanied to the pastures again. In the morning the west-exposed and in the afternoon the east-exposed pastures are visited. The reason for west-facing grazing in the morning and east-facing in the evening is that grass is moist at these times of day. This is also why at noontime animals are not on the pastures. Herding is mostly the task of the land user's sons and grandsons, but sometimes he will accompany the animals by himself. The animals are led slowly so as to not tire them, to make them fatter and to avoid damage to vegetation. The same rotational scheme is applied throughout the year, which means that the same pastures are visited daily.

These communal pastures are far off (one hour) from the next village and snow lies longer in spring than further down. This means that the village herd only comes here from late spring to late summer, which decreases the pressure on the pastures. Together with the situation in a small depression that protects from high radiation in summer this contributes to the generally better pasture quality (greener, more grasses) compared with the village pastures in proximity to the villages (compare figures 53 and 54). An important factor contributing to the generally good conservation state are the reduced livestock numbers. The advantage of the land user in his opportunity to use these pastures is that the land of his farmers' association and his hut are next to the pasture-area, whereas herders from the village have to walk quite far to reach it.

The most important objective for the land user is to make a living for his family (himself, his wife, his sons and their families). Animal husbandry is an important part of his multistrategy (orchard, kitchen garden, haymaking, grazing). He wants his animals to be fat and healthy and measures the success of his work by the prices obtained on the cattle-market. Further, he does not want that animals damage pastures by too high numbers or too early grazing (in spring). For example, vegetation cover is important for him, because it is a protection of soils against frost, it is the best reservoir of seeds and it provides manure for other plants.

The most important method is the land user's own initiative, since administration tends to be a handicap rather than a help. The land user understands himself as someone who reflects on problems and searches for solutions. As an example he mentions the visible damages caused especially by cows if they are led to the pastures too early in the season. He does not lead his cows to the pastures before May because of this and he recommends the villagers to do so, too, for the village herds. For him, it is necessary to learn from the environment. He is also convinced that in the new economic reality after the breakdown of Soviet Union, initiative and entrepreneurial spirit are necessary for success.

Figure 54: Stable where the animals are kept at noontime (below) and green pastures nearby (above).

4.6.3 Grazing rotation on forest administration territory

The case study with the technology called *"Daily and seasonal rotation on grassland"* and the approach of *"Seminomadic individual herding"* focuses on 300 ha of the forest administration territory. It is grassland with a rather high proportion of natural trees, where few signs of the (original) target of forest administration are still visible: remaining terraces and little platforms for tree-planting. At present, parts of the territory of forest administration are under grazing use, even if the institution claims that the area with its often very white loess soils is not suited to this use. The herds grazing here are often from other districts (as for example in figure 55), following a very old transhumant tradition, not interrupted by Soviet Union. The LUS used by the herder are semino-madic areas, marginal areas and resting places.

The herder, who is from one of the villages in the study area, has been a professional herder for more than twenty years and has elaborated his own grazing rotation. He works with 500 sheep, goats and (very few) cows, with seven to eight different locations where he moves his tent (see figure 56). The herder normally stays in one place for 10 – 14 days, maximally one month (during the Ramadan period, due to limited forces). The area is grazed from the higher zone (around 2100 m) to the lower zone (around 1600 m) twice per season, in a sort of circle. Every day the herder starts in another direction from his tent and leads the animals to the pastures, once in the morning and once in the evening. He passes a stream once (autumn) to twice (summer) a day with his herd.

The criteria for changing places are dusty grass and the wind starting to transport away soil. This is also why he only visits the same pastures every two to three days during the time he stays in one place. The herder chooses his 300 ha territory every season: by the criteria of biomass, vegetation cover and availability of surface water.

The establishment of his herding system is based on experience and the maintenance of pastures is guaranteed by the herder's strict rotational scheme. After accompanying his father as a child and a kind of apprenticeship (of one year) later on, he is considered by the villagers as a good herder and they give him their animals for herding. With the generated income as a herder he can then gradually build up his own herd. For the herding profession, observing the animals precisely is necessary in order not to lose any of them. For this herder it is especially important to be sincere with the tenants, to give them back the right animals and, if not, to pay for lost animals.

Every method applied serves the target of having an obeying herd. The herder works with a lot of patience. In the first two weeks of the season he pays very much attention to keeping the herd together, so the animals get used to each other. The rotational grazing scheme also fulfils the requirement of fattening the animals. Grazing the animals by nighttime is a further method to make animals obey better. The animals are, by the way, not led or chased by the herder, but rather accompanied by him.

The pasture-area is in a generally well-conserved state. Moderate to high values of fractional vegetation cover can be observed and only few signs of recent erosion processes (through water) are visible. The area is characterised by steep slopes where signs of past tree-planting during the USSR period are still visible by some trees, many little platforms (smaller than terraces) made for tree-planting and a few terraced areas. The dung left by the animals, not collected as in areas close to villages, contributes to soil fertility. It favours palatable species and somehow compensates for the fertilisers applied in the Soviet era. The rotational scheme has the advantage of causing much less trampling paths than observed on overgrazed village-pastures.

Figure 55: A herder from a former collective farm in the South, with his sheep and goats.

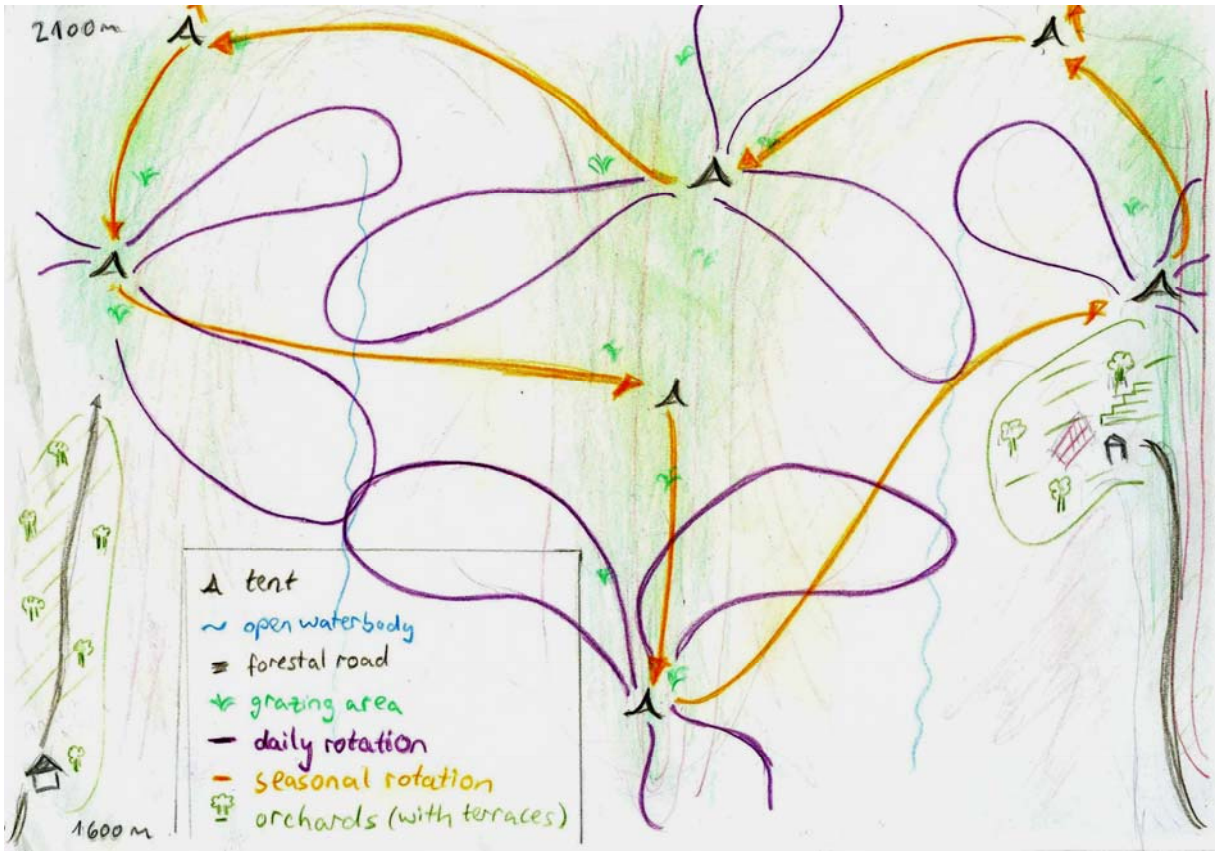

Figure 56: Grazing management, based on daily and seasonal rotation.

Many trees have been damaged by grazing, however, and some have not survived. In contrast to the slopes there are small, quite flat areas (where the herder installs his tents), that used to be cultivated (wheat) till 1966. These areas generally have low cover values and signs of rill-erosion, which the herder mainly attributes to the past tilling activity. The damage is also caused by grazing: especially horses and donkeys rooting out entire plants. In these places weeds appear stronger and during strong rains there is topsoil erosion. Degradation problems especially occur during the first spring rains when the rivers are full of water and cause erosion. At the same time these rains are important as they let vegetation become denser and higher.

According to the herder, there are also problems with pests and diseases that damage vegetation, especially in places not grazed at all. Another problem are landslides occurring on former cropland where wheat used to be planted back to the 1960s (when there still used to be villages in the hills). Landslides occur during long rainy periods when the soil is saturated. On the old cropland soil is not sufficiently stabilised according to the herder and can easily be eroded. Trampling of his animals contributes to stabilising the soil. He claims that where there is no cementing of soils by grazing, gullies have formed. For him, the often invisible terraces established in Soviet times are substituted in their function by grazing animals. In addition he says that twenty years ago there were more and bigger herds in the area, especially from state-farms of other districts.

4.6.4 Food, fodder and research in an orchard

In a *"Combined cut-and-fodder and fruit-production system with terraces"* (technology) research and production coexist on a *"State-controlled research territory for orcharding"* (approach). There are two such areas of totally around 90 ha. The whole territory is conceived as a research station. The case study looks at the area of mixed production next to the village Karsang, corresponding to the LUS fruits and haymaking. The orchard-area is 30-50 ha, depending on how strictly it is delimited. The area is situated on a ridge used for haymaking, but is accessible for animals from the village.

Fruit and nut trees give the production system the characteristics of an orchard, whereas sour cherry trees rather provide for a jungle atmosphere. They spread very quickly once they are established. By their stabilising function trees prevent soil from being washed out. Especially nut trees with their 20 to 25 m long roots preserve soil moisture and by that consolidate soil structure. Hay production substitutes other uses of the lowest vegetation layer, since grazing is forbidden. Haymaking does not damage soils and is only allowed after the end of June so that grasses can reproduce. Terraces contribute to this moisture-preserving and production-enhancing function. They are very important in order to make rather steep land exploitable by reducing slope.

Both the establishment of terraces and the planting of trees on such a big surface are costly in terms of labour and money. Maintenance means taking care of trees, taking measures against pest and conserving soil fertility. Fertilisers are very expensive and therefore dung has partly been substituted for them in the last years.

The research station was established in the early 1960s. After building a terrace the trees were planted, then the next terrace was built and so on. The orchard needed to be maintained: among other measures annually around 10 – 15% of the trees are substituted and fertilisers, manure and pesticides are applied. When trees are not yet fully grown, intercropping is possible. Since 1992 soils on the terraces are not tilled anymore, because the trees are too high. In addition, in the last years it was too dry and only 5 ha of kitchen-garden (from the workers) could regularly be irrigated. During civil war, when the district government was nearly inexistent, the land needed to be distributed among the employees, who were now land renters and had to maintain their part of the orchard by themselves: It was the only way to protect the orchard from being destroyed, says the research coordinator.

Work is subdivided into research, whereby the analysis of soils is carried out in laboratories, into conservation methods carried out by field staff and the research coordinator himself (planting fruit and and other trees, grafting fruit trees, planting and maintaining tree saplings, combating pests and forbs) and harvest (of fruits and hay) that is carried out by all the employees and their families together with seasonal harvest labourers. The fruits are partly dried and sold (see figure 57).

The main objective of the research station is to dispose of varieties of fruit trees adapted to different conditions. This is guaranteed thanks to two research territories, the one next to the village Karsang (assessed in this case study) and a second one higher up in the hills. Another objective is to prevent degradation, to test methods of rehabilitation and to spread this knowledge. These objectives are pursued by the technologies of terraces and of planting sour cherry trees. Initially the orchard was also implemented as a source of labour for 50 employees. In the last years it has become more important to acquire self-sufficiency by fruit and hay production, because wages cannot always be paid. And because of limited state support in terms of fertilisers, pesticides and machines, the selling of tree saplings is important.

Despite the protection of soils by trees, the head of the research station complains about problems with wind erosion. And with its strict conservation measures the research station is a green spot where it is tempting to graze animals. But overall the research station can be considered as one of the bright spots of conservation in the study area.

Figure 57: Tree nursery explained by the research coordinator (left) and apricots drying in the sun (right).

4.7 Comparison of case studies

In these four situations there are common motivations but also differences. The activities of all persons described in the case studies are mainly concentrated on the agricultural sector with an important share of self-sufficient activities. But financially the dependence varies much: between the professional herder whose main income is livestock fees paid to him and the village herders who ensure their access to the common herding system by their work, without earning money thereby. In between these two cases is the orchard research station whose employees more or less depend on their salary, respectively on the sale of products from the orchard on the local market. And the mixed strategy of the family living in the hills relies both on selling livestock and fruits and vegetables and on self-sufficiency.

Financial possibilities are one among other important criteria to implement SLM. Besides money there are other factors:

- The possibility of improving his own reputation was important for the academic who built up a farmers' association in hard work, against the opposition of administration (see chapter 4.6.2). A man, not described in the case studies, planted trees along the path from the village to his orchard (several kilometres) for the same reason: People would have a rest under one of the trees and remember the man who planted them;
- Traditions are very important to explain rotational grazing as described in chapter 4.6.3: The herder is sure that his father's rotation was the best one existing, so he will always try to follow this example. Traditions are also important in common herding, as the rotational schemes described in chapter 4.6.1 partly date from before USSR;
- Self-sufficiency together with improving the livelihoods of one's own family on the long term is important for the land user who built up a combined agro-silvo-pastoral system *"for his sons and their families"*; as he affirmed;
- Production is important in all case studies: herding must provide for meat and milk for many peoply. And the orchard must result in high yields; otherwise the employees would not give the dung from their own stables to the institute's trees. The bigger the production, the more can be sold;
- Ecological motivation is important in discourses: an employee of forest administration mentions the importance of trees to protect the white soils from being washed out. At the same time several land users mention that wardens (from the same administration) can easily be bribed to cut down a tree. Of course ecological problems and their effects on production are perceived. But the implications on land use are primarily understood as limitations: if you have the means to buy more livestock, why should you keep less livestock?

This incomplete list of factors shows that theoretically land users are conscious of the fact that well-maintained soils and vegetation are a condition for high yields. But implementing this idea is difficult. There are though examples of successful conservation – both in productive and ecological terms: a good example is the research station and the LUS "*Fruits and haymaking"* in general, which provide families with fruit and animals with fodder for winter. And they show little degradation compared with all the other LUS. But also seminomadic herding in general and the grazing rotation already described in particular are successful in terms of fat animals and high cover values of the used pastures. In case of daily pastures the difference between common and family based herding is considerable, especially in productive terms: The land user who established the very basic rotational system is proud of his goats: he sells his animals at double the price of animals from village herds. The better conservation state of the pastures used by him compared with the pastures close to the villages is also a matter of accessibility and other factors such as:

- Finances: The measure is either cheap or externally financed (for instance by remittances). The assessed case studies on herding are constituted by more or less cheap measures: the use of child labour or the rental of land is cheap, but paying a professional herder is not affordable by all land users. And the research station depends on subventions;
- Labour availability: The establishment and maintenance of both orchards and grazing rotation require professionals and they constitute a full-time job in summer. Even if professional herding is better paid than other jobs it requires living alone in the mountains in many cases, explaining why young people often prefer a job in Russia or in town;

- Accessibility: Low accessibility, be it by steep slopes or by far village distances, often reduces land use intensity. This is clearly shown in fire risk maps of forest administration that indicate lower risks for remote areas. It is also seen in the good conservation state of the pastures used by the professional herder alone. Non-accessibility makes areas less attractive to use. A herder met in the upper hills proudly claimed that unlike the herders of the big village herds who could not reach these areas, he came daily to this place from the village;
- Land regulation enforcement: In case of the research station a generally acknowledged prohibition of grazing is effective thanks to the employment of three guardians, despite its closeness to a village. In case of a piece of former cropland that was planned to be converted into an orchard, an elderly man passing at least once daily in the orchard cannot stop the village herd entering the field;
- Entrepreneurial and fighting spirit: Especially for individual land users and their families it is difficult to enforce new management measures: against the opposition of land use and tax administration and of other villagers. According to the land user with the farmers' association (see chapter 4.6.2), he had to replant parts of his orchard which had been burnt by envious villagers;
- Relationships to administration: Several interview partners mentioned the advantage of having friends in land administration when it comes to starting an SLM project or founding a farmers' association. The professional herder says that he could easily rent land for herding, because forest administration knew him from his time as a tractor driver and had built up confidence in him.

As can be deduced from these success factors, common herding is not very successful in implementing conservation. According to villagers the price for a better conservation state of daily pastures and the risk of losing control over the pastures would be high: rehabilitation of tree cover through the temporary prohibition of grazing enforced by forest administration or expensive enclosures around planted trees are some fears. This explains that the perspective of villagers on conservation is very different from land administration's perspective:

- Many land users are driven by the hope of acquiring land for long-term rental to establish a farmers' association that will be theirs. This means that conservation is interesting if they get returns, be it by clear land tenure with reduced rent fees, by products and by contributing to ensuring the livelihoods of their family.
- At the same time some villagers and even a village chief are afraid that they will not be one of the lucky ones to have their own orchard, be it for the lack of either financial means or relations. They critically observe how areas under private use increase at the expense of the public pastures. And they know that every additional farmers' association means the transformation of former pastures or cropland where crop residues could be used (for haymaking or grazing) into inaccessible areas.
- The forest administration as well as the land use committee on the district level plead for top-down measures that should be enforced: be it the commitments of villages to convert parts of their former cropland into fodder-production areas or the prohibition of cutting down living trees. In the orchard research station there are fines for illegal grazing on its territory.
- The enforcement of land regulation is criticised by villagers. Some of them mention corrupt functionaries not assisting them in questions of land use, but rather focusing on raising taxes and bribes. Village chiefs that are in contact with the local land department (Jamoat) are very critical about administration and are afraid to declare to them true livestock numbers because of taxes that might be increased.

5 Discussion

First answers to the initial objectives and research questions are given. Then hot spots of degradation and bright spots of conservation are identified by comparison with other studies in Tajikistan. This is followed by a critical reflection of the applied methods and field work.

5.1 Answers to research questions and objectives

1) A spatial delimitation of existing Land Use Systems (LUS) for grassland, based on management.
    - By which criteria can a LUS on grassland best be visually and spatially delimited?

As discussed in the previous chapter, the delimitation of LUS is a challenge especially because of the big mapping units. The most important criterion used in the field was vegetation cover that can be estimated from a distance. The problem here is that during the study season vegetation cover constantly decreased. The second criteria was slope that especially helped to sort out marginal and barren areas and turned out to be little helpful to discriminate pasture LUS which are highly variable in slope. A third important parameter was vegetation: fruit and haymaking areas are characterised by geometrically planted trees, haymaking areas by a generally higher proportion of trees than pasture areas and resting places by a very green colour and single planted trees, often mulberry trees. Village chiefs that know best know the borders of pasture, cropping and haymaking areas were further important sources of information.

2) A spatial analysis of selected conservation measures and degradation indicators.
    - How do values for the different indicators change depending on the LUS?

Degradation indicators generally have higher extents and degrees for LUS on pastures than on cut and carry systems. But seminomadic areas appear well-conserved and former croplands, now partly used for haymaking, appear highly degraded, especially because of their past use. Especially degradation of water and vegetation resources and of animal and plant life is accentuated on trampling paths and daily pastures, whereas seminomadic areas and cut and carry systems are much less concerned. The steep slopes of marginal areas are especially prone to water, but also to the degradation of soil life. Soil degradation, especially compaction, is more regularly distributed.

Conservation measures are concentrated on cut and carry systems where grazing periods are mostly strictly regulated. In pasture areas seminomadic pasture use appears as a well-conserved LUS. This has to do with regulated grazing periods and reduced livestock numbers, but also with selective use due to inaccessibility. Resting places in some cases do not suffer from the same trampling frequencies and animal numbers as the daily pastures closer to villages. At the same time their greenness has much to do with the prevalence of *Cynodon dactylon* and with their situation nearby streams that provides them with moisture. Daily pastures and trampling paths are exempt from conservation measures, if the low efficiency of rotational schemes applied is considered.

3) An aggregation of impacts of conservation and degradation on ecosystem services for each Land Use System.
    - Which are the impacts of different LUS on selected Ecosystem Services (ESS)?

Trampling paths, daily pastures and former cropland show the worst performance in terms of ESS whereas for cut and carry systems together with marginal and seminomadic areas net values of ESS are around zero or even positive. White soils are frequent on daily pastures and trampling paths and have a very negative impact on organic matter and soil structure. Seminomadic and haymaking areas especially suffer from dried out soils affecting drought resistance and soil structure. In marginal areas flood regulation is reduced, which is a question of high slope values. Production is affected by bush encroachment and non-palatable species, which is also a problem on former cropland. The latter especially suffers from degraded soils.

Despite the negative impacts described, conservation measures and even selective use (that cannot always be documented as conservation measure) can result in net positive impacts on ESS. This is the case for natural trees that have escaped being cut down in parts of marginal and seminomadic areas, which have a positive impact on ESS. Therefore seminomadic areas with little observed conservation measures in the field have a positive impact on ESS thanks to selective use of vegetation. Blackish soils, frequent on resting places and in orchards, cause positive impacts on organic matter. On parts of former cropland haymaking yields positive values of soil cover. Efficient conservation measures in cut and carry systems not contained in ESS calculations might be the reason for observed values of production being higher than the calculated ones. In this context the combat of pests and the application of fertilisers in orchards are important to mention.

More in general, field assessments of ESS result in more negative impacts of degradation and more positive impacts of conservation on ESS than the calculations according to table 8. This might be a question of perception, but also of additional decision criteria used in field assessments, but not included in the calculations such as (for conservation) grazing management measures, dung and (for degradation) reduced plant and animal life.

4) A comparative assessment of 4 case studies of grassland management.
    - Which conservation measures are interesting in ecological as well as in productive and economic terms?

As seen in chapter 4.6.5 productive-economical and ecological aspects are only two among a series of factors that influence a land user's decision to implement SLM. It is difficult to identify conservation measures that are cheap and profitable both financially and in the sense of ecological improvements!

Fruit and haymaking areas might be closest to these criteria because haymaking has proved to enhance biodiversity and soil quality and provide for fodder, and fruit-production can generate surplus production of fruits sold on the market and additionally wood (of the cut trees) that can also be sold. But it is relatively expensive to acquire land for long-term renting to plant and maintain trees and requires high labour inputs. And for the land users who cannot afford to rent land on the long-term or who lack the necessary contacts and knowledge to build up a farmers' association more such areas mean less space for common herding.

Strategies only concentrated on grassland are successful in ecological terms if they combine the reduction of grazing periods and of livestock numbers such as is illustrated in two case studies (chapters 4.6.2 and 4.6.3). For the animal owners it means either high inputs of labour (by organising herding) or paying per capita livestock fees that not all of them might afford. The economically cheapest system is the rotational herding system of the villages, but its ecological performance is negative and returns in terms of milk and meat production are reduced. This makes clear that an ideal solution for all land users practising animal husbandry is difficult to find.

5.2 Hot and bright spots in review

Common pasture areas as the identified hot spots of degradation are analysed in comparison with the study carried out by the national rangeland consultant Madaminov on a part of the assessed pastures in 2005. This is followed by an analysis of ESS on the basis of a hot and bright spot concept of Wolfgramm (2007).

If erosion phenomena are looked at more closely, it makes sense to consider trampling paths and daily pastures together as a part of communal pastures. According to Madaminov (2005), who was active in the same area for FAO, "*more than 50% of pastures look like animal paths"*. The land user using village pastures with a low proportion of trampling paths (see chapter 4.6.2) says "*I always lead my animals along a different way. Why should I need trampling paths?*" It can be seen as a logical consequence of daily herding to have trampling paths: with large herds and daily changing herders and herd-composition, the easiest thing is to use always the same way.

Madaminov (2005) especially mentions erosion by water as a problem on such pastures: a degradation process that was observed less than others in the chosen study period (summer). Spring rains often trigger these processes. Especially physical soil degradation and the degradation of vegetation could be proved. And if biomass reduction on trampling paths appeared to be less severe in terms of cover compared with other pasture LUS, this is because in the case of no vegetation cover at all there cannot be degradation of plant biomass.

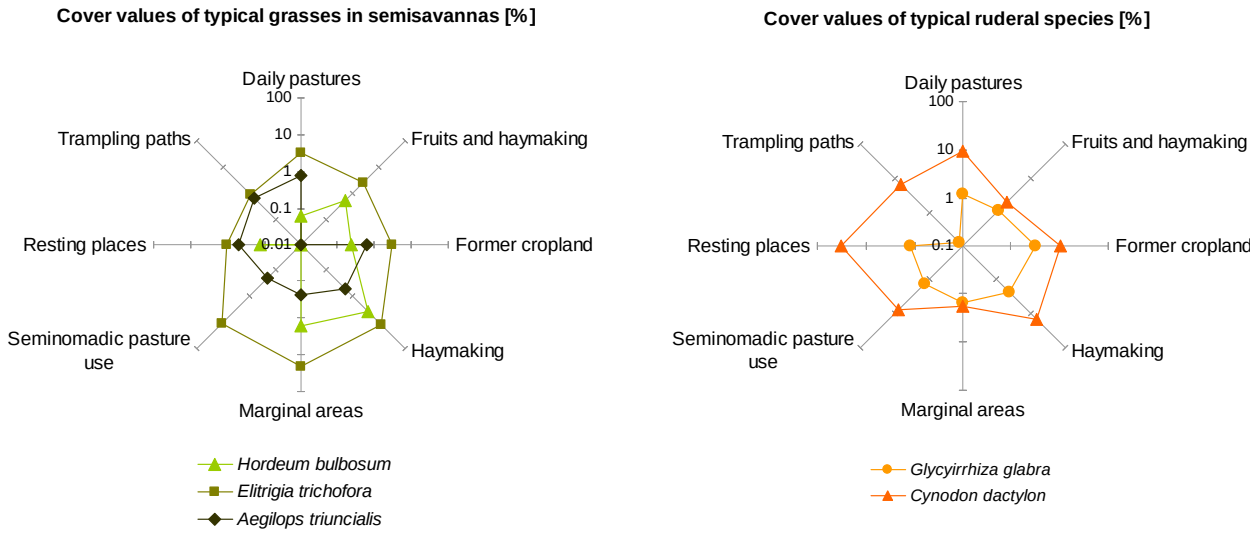

Figure 58: Species typical for natural vegetation (left), respectively for intensively used vegetation (right).

Whereas in pasture areas degradation is more associated with grazing, in cut and carry systems the intensive use of vegetation as fodder strongly influences vegetation state. And in marginal areas but also in seminomadic areas natural causes, especially topography (steep slopes), are a major degradation cause. But in all areas droughts are a major preoccupation, with crop failures and reduced production on haymaking and pasture areas. Even orchards heavily suffer from water shortages, because they cannot be irrigated anymore. The question remains if trends, especially the decrease of rainfall on the long term mentioned by many land users, or variability – *"Climatic indicators and productivity of plant formation are fluctuating every season and every year"* (Madaminov 2005: 5) – are more important in explaining the very dry conditions in 2008. In any case both variability and droughts seem to be a future challenge. And already degraded land can be assumed to be more vulnerable.

The question remains which LUS best manages to reduce degradation in terms of ESS values. A good validation of the assessed ESS values (especially for organic matter) is possible thanks to the hot / bright spot map produced by Wolfgramm (2007) on the basis of Soil Organic Carbon (SOC) spectrometry. Wolfgramm distinguishes between four categories that are enumerated by decreasing SOC content: "*bright spots of conservation", "stable areas", "degrading areas"* and *"hot spots* of *degradation*". If the 80 sampling sites of this study are overlaid with the SOC map of Wolfgramm, they can be attributed with these categories. The results can be compared with the photo and field assessment based estimates of soil colour (and thus of SOC), used for the ESS Organic matter. The easiest way is to compare how many points categorised in this study as "*black"* (according to table 8 in chapter 3.4.4) correspond to the classes of bright spots and stable areas of Wolfgramm, having high SOC values. The same matching is performed between the category "*white"* and degrading areas together with hot spots (see figure 59).

The comparison shows that low SOC contents are better represented by field assessments, respectively estimations based on photos, than high ones. The error-rate, that is the non-matching of the two methods' results, is high (39%). This means that especially the estimation of the ESS *organic matter* might be incomplete. Nevertheless the SOC values are reflected in general LUS patterns. In figure 60 the four SOC classes of Wolfgramm are represented. Whereas LUS with high cover values and little washed out soils are often in the class of bright spots, frequently used pasture areas together with former cropland are often hot spots of degradation or at least degrading areas in terms of SOC. It is astonishing that haymaking and marginal areas have a lower proportion of bright spots than of resting places. This might have to do with nutrient inputs of herds regularly passing the resting places and leaving their dung.

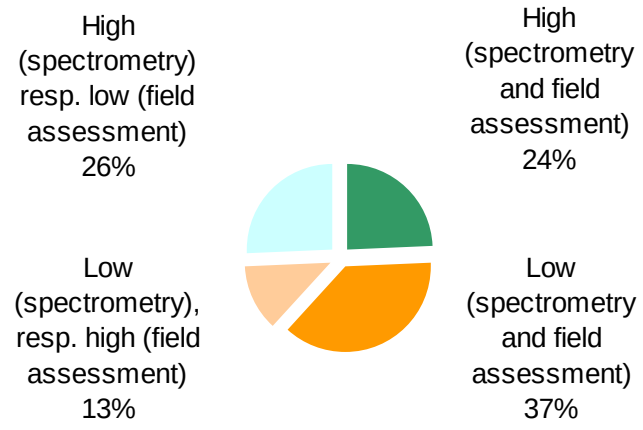

Figure 59: Matching of field assessments and the SOC-classes of Wolfgramm (2007).

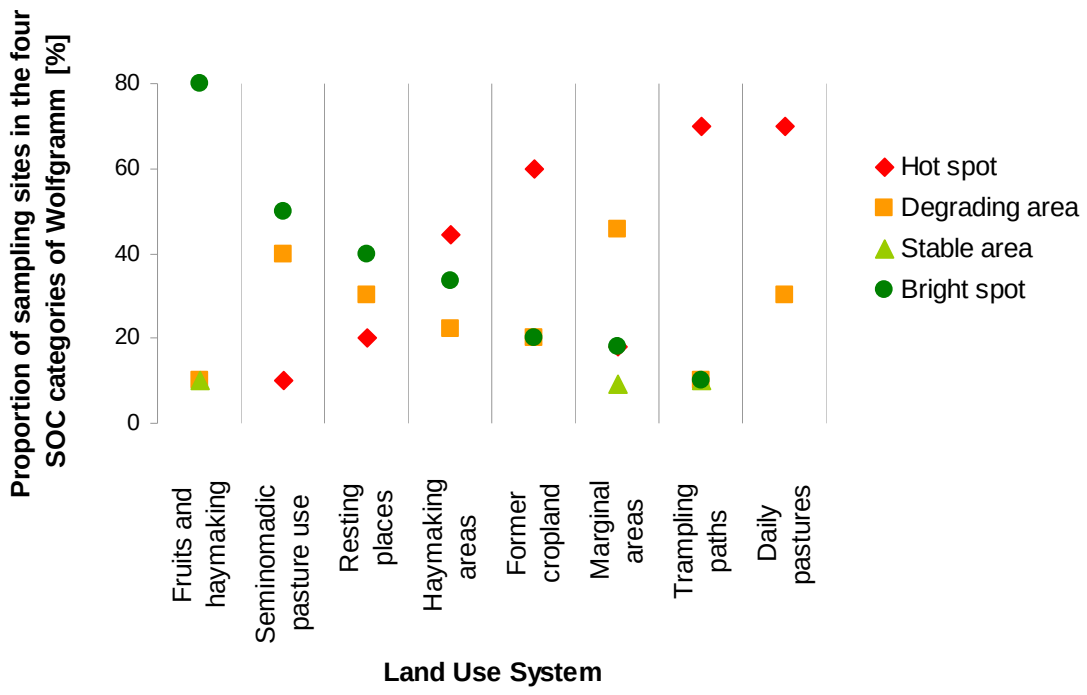

Figure 60: LUS with regard to SOC-content, sorted according to the proportion of bright spots.

The impression of the best-conserved fruit and haymaking areas given in figure 48 is confirmed both by land users and observations from sampling sites. They judge no grazing at all, especially if it is implemented by fencing, to be the most efficient conservation measure in terms of soil and vegetation resources, together with vegetative strips: both parts of the strategy of orchards. This does not mean that these are the most efficient measures in terms of spatial extent. The most widely spread conservation measure is the control of grazing periods by very easy rotational schemes applied on daily pastures or by strict grazing periods in haymaking and cropping areas, limited to late summer. The second most spread grazing management measure is the control of livestock numbers, whereby efficiency is higher in combination with controlled grazing periods.

The conservation measures mentioned are mainly based on traditional knowledge and often based on limited inputs. Especially the grazing management measures, except fencing, do not require the input of qualified labour and are cheap. And costs seem to be a strong limitation for conservation. Even members from administration complain about lacking financial means for state-implemented conservation: whether for tractors to build and maintain terraces or in terms of their salary which does not permit them to make a living and thus requires additional income sources such as bribes, as is mentioned by villagers. Another important limitation for conservation is the unclear legal situation engendered by the very long reform process of land regulation: it implies that farmers are insufficiently informed about their rights and duties if they found a farmers' association and that they often feel neglected by administration whom some of them accuse of being corrupted and charging too high fees.

5.3 Methodological reflection

A series of difficulties emerged during field-work which will be shortly described. A first group of problems is associated with questions of interaction with people, followed by methodological challenges.

Besides the language barrier, reduced thanks to a translator, a cultural barrier sometimes made it difficult to address the wishes of working partners: be it interviewed land users, the translator or the field assistant. It was sometimes difficult to impose decisions in front of an experienced and much older translator without appearing too authoritarian: for example, when questions of salary, tasks and distances to walk had to be clarified. One example is the selection of sampling sites that should be well distributed over the whole assessment area without entailing too far daily walking distances. Another step was to learn that interview partners would not say when the maximal conversation time for them was exceeded, but would feel offended. This problem was aggravated by the fact that most interviews took place during the period of fasting, when people were anyway tired and had dried out mouths.

Another difficulty both interviewer and interview partner are confronted with is social expectancy. An example are employees from forest administration, who tend to declare that there is no grazing on the territory of forest administration from Faizabad because grazing is forbidden there, even if there are animals grazing. Or livestock numbers are not honestly given, since people fear that the numbers will finally reach tax administration. Only when a village-chief understood that the researcher is not going to tell the numbers of the village's livestock to local administration, would he admit that the effective numbers are much higher than those delivered to local administration (Jamoat). In addition, the same family might consider itself to have much less animals than the neighbour or another villager. It is very different with livestock numbers in the past: many land users claim that there were more animals in the villages and herds coming from the South in the Soviet period, which might just be explained by the generally positive attributes given to this period.

The methodological design revealed difficulties in several aspects. The first difficulty was to find a compromise between detailed interviews with open questions on all aspects of the WOCAT questionnaires and asking whether certain aspects are right or wrong (with the risk of giving certain suggestions). This is especially true because the questionnaires have partly very specific contents, for instance on ESS, that must be transformed into easy questions. The concept of ESS turned out to be difficult to explain to local experts. And some aspects especially of the approach questionnaire obviously annoyed the interview partners, as for example the question of (mostly absent) subsidies that for land users seemed to be an exaggerated question. Generally, they also preferred not to talk about about pasture problems. Very simple questions sometimes helped to get answers: It is better to ask a land user on which pastures cows get the fattest than how he would define good pastures.

The ESS assessment method is another problematic aspect: Due to rough estimations in the field with ad hoc criteria rather than an ex-ante classification scheme, ESS had to be calculated after field work. A very simple calculation of ESS (see table 8 in chapter 3.4.4) is developed which cannot take into account ecosystems' complexity: first of all a state indicator's influence on ESS is not always the same (for example +2). It depends both on the degree and extent of degradation and does not follow the uniform thresholds defined. And not all necessary indicators are integrated.

In addition, for a few state indicators the assessment was too simple or incomplete: the categories for the indicator *"Loss of soil life"* yielded a degradation extent of 100% for many LUS, which does not permit differentiations between LUS to be made. Or organic matter was partly estimated by studying the soil colour on photos which can vary with changing daytime and for which it is difficult to define a threshold between black and white soils (see table 8). In addition there are red soils very difficult to classify with regard to their organic matter content.

Another difficulty was the visual LUS classification. LUS on grassland are characterised by high internal variability: the distinction between haymaking areas and pasture areas seems to be easy at first view, because in pasture areas there are generally signs of grazing, as for example trampling paths. But in remote areas (of forest administration) the use is often very selective, be it as pastures or for haymaking, making it difficult to find out how they are used. The distinction of the LUS inside these big groups is even more difficult, because the borders are not fix: it is not as clear where a resting place passes into daily pastures as the borders of a crop-field can be determined. This is even more obvious when former cropland is mapped: it is not clear which former cropland is still used for grazing, despite the fact that land administration wishes the areas to be converted to cut and carry use. The orientation on a false colour satellite image is another difficulty, especially at the beginning, and also for local people interviewed.

The choice of sampling sites is not easy either: first, the land cover classification of Wolfgramm (2007) provides little points for small LUS such as trampling paths. This makes necessary the choice of many additional sampling sites, according to the selection criteria of chapter 3.2.2. Second, it is difficult to get access to more remote areas in order to obtain better spatial representation, for this often requires overnight accommodation. An elderly translator or field assistant is not necessarily willing to sleep outside somewhere in the mountains. More in general, the field-protocol to be filled in turned out to be very labour-intensive, especially the part about vegetation. It required one and a half months of field-sampling and delivered a quantity of data too large to be entirely analysed. This shows how important a good preparation of field-studies is.

6 Conclusion and Recommendations

This study provides knowledge on the different uses of grassland in a study area of 10 by 10 km in Faizabad, Tajikistan. The mapped area of around 50 km^2 is composed of pasture-areas and areas for fodder-production of each between 20-25 km^2. A selection of existing conservation measures was analysed as to their capacity to reduce degradation and to provide for food and fodder.

The following conclusions on conservation strategies can be made:

- Efficient management strategies in terms of conservation are found in the areas selected for haymaking or rented by individual farmers for haymaking and / or fruit-production (orchards);
- The quality of pastures generally increases with increasing village distance and lower accessibility for daily grazing. This also has to do with stronger regulation of the areas belonging to forest administration: Here herding is organised by seminomadic herders, which follow more or less strict rotational schemes.
- Pastures close to the villages underlie a very limited management which principally focuses on grazing periods: According to different village-chiefs there is no grazing in winter in the most places. Grazing periods are often defined by committees composed by villagers. Livestock numbers are not controlled.

The lack of management measures on frequently used pasture together with increasing livestock numbers of the last years since the end of civil war led to severe degradation of soils and vegetation. This endangers the livelihoods of all the people depending on animal husbandry and thus a great share of village population. It makes them especially vulnerable to natural hazards such as the drought in 2007-2008, which accentuate the problem. Several farmers said they had to sell animals due to reduced hay yields and their inability to buy fodder for winter.

This means that the need is to improve the quality of such pastures, for instance by controlling livestock numbers. Therefore alternative income sources to livestock are needed to generate a minimal income to buy school material or to finance medicine. Remittances (especially from Russia) make an important part of income and of investments into livestock (see also Schoch 2008). But the economic crisis is making many migrants return from Russia. The fact that Faizabad has no industrial basis (except an egg factory) and no investors makes the situation even more difficult.

The following recommendations can be made for possible projects in the area:

- It is very important to collaborate the local and district-level administration, especially land use committees and forest administration, and with local people. Faith in administration must be built up in order to realise successful projects that will always depend on the goodwill of these institutions;
- Initiatives taken by villagers must be facilitated by administration. A positive sign in this direction are land users starting to build up farmers' associations (dekhan farms). The problem here is that the legal framework is currently being transformed and is not well understood by local land users, which makes them subject to abuses. For instance the heads of such associations are convinced that land belongs to them even if in Tajikistan land is still state property;
- The potential of the area must be detected. There are further possible uses of agricultural products such as transforming the lots of unused fruit remaining in orchards to dry fruit or to tinned food. And instead of clipping the wool of an increasing number of sheep and leaving it behind on the pastures, it could be processed to wool. Labour force (especially of young men), though, is a limitation to be taken into account;

- Off-grazing activities must be developed to decrease grazing pressure. There are innovative people that might be interesting partners in a project: a man willing to build a wind-mill, a land user (described in chapter 4.6.2) wanting to exploit a source for mineral water and perhaps many more. They are waiting for administration to understand that such initiatives can help a whole village and should not be punished by high taxes;
- A focus on women and training is necessary: with many men staying in Russia, women are the backbone of agricultural and domestic work: They transform milk to yoghurt or cream, flour to bread and they collect forbs on crop-fields as a winter-fodder. Women also help building houses and they accompany the village herds, which are both considered to be male tasks. Their knowledge constitutes a potential (see also Maselli et al. 2005).
- Herders must be provided with knowledge, for example through training. There are few experienced herders and even some of their practices are questioned by experts: is it really necessary to teach sheep to obey by herding at night-time and risking their health because (according to herders) they cannot discriminate less palatable from more palatable species then? In many cases pasture degradation is not perceived as a problem of over-exploitation of resources, but rather as a part of natural dynamics (droughts) (see also Liechti 2008A). This is why land users accept pasture degradation as long as their animals survive. Bringing animals through winter is often more important than having fat animals (see also AKF 2007).

The assessed case studies give ideas for SLM in the future. Orchards with haymaking are increasing in extent. Grazing rotation is little spread and could be developed on two axes, as proposed in a study (see AKF 2007): either by changing grazing and haymaking areas over time or by establishing a rotation within a fixed area and with different grazing places such as proposed in a case study (see chapter 4.6.3). A consequent rotation and regular change of grazing places is considered in the study of AKF (idem) to be more promising than a limitation of livestock numbers, this being very difficult to implement without the support of villagers:

> *"There are no community mechanisms used to limit the numbers owned by any individual. Only the pasture tax penalises livestock ownership because […] although it is paid per hectare in theory it is paid by head in practise"* (AKF 2007: 37).

Grazing management projects of CARITAS in Southern Tajikistan did manage to regulate livestock numbers in a participative approach, by explaining to livestock owners the tragedy of the commons in simple words. A specialist from this organisation further mentions the possibility of extending pasture carrying capacity, for example by introducing leguminous plants or fodder trees. Mulberry trees (*Morus alba*) are an example of such trees, already used in Faizabad for silkworm production (leaves), as an energy source (branches burned) and as shade trees. Their leaves are nutrient-rich fodder (for further information see Jenet 2005). The evolution towards semiprivate pastures grazed by a farmers' association (such as described in chapter 4.6.2) is another possible evolution.

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Appendices (on an enclosed CD)

Appendix 1: 4 pages' summaries and images of the case studies (pdf-files)

Appendix 2: ESS values and the contributing indicators (xls-file)

Appendix 3: Plant list with photos and the species' palatability (pdf-file)

Appendix 4: Degradation and conservation data for 80 sampling sites (xls-file)

Appendix 5: Digitised LUS map (Shp-files)

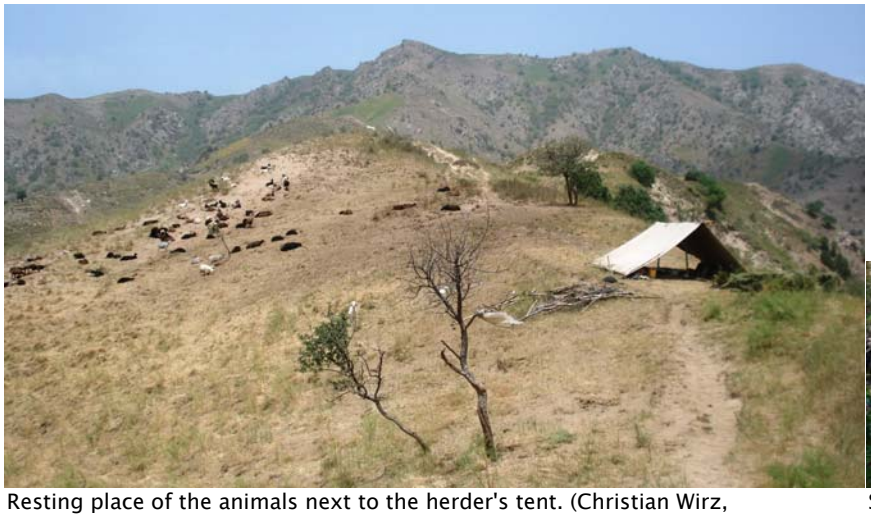
Appendix 6: Livestock numbers of the villages in the study area (xls-file)

Appendix 7: Livestock distribution in different villages (pdf-file)

Appendix 8: Digital version of the Master's thesis (pdf-file)

Appendix 1

On the following pages, short summaries of two case studies are given. First, the case study described in chapter 4.6.3 and then the one from chapter 4.6.4 is presented. The questionnaire on the SLM technology is presented before the questionnaire on the approach for each case study. The summaries of all case studies can be found on the enclosed CD.



Resting place of the animals next to the herder's tent. (Christian Wirz, Switzerland)

Sheep and goats grazing in a high-cover area. (Christian Wirz, Switzerland)

Daily and seasonal rotation on grassland

Tajikistan Dajmardei Kaspi (professional herder)

Extensive grazing of sheep and goats by the means of a precise rotational scheme

Description:
Half-year herding with 500 sheep, goats and cows (very few), with 7-8 different locations of the herder's tent. The herder visits each place twice to thrice per grazing season and stays in one place for one week to maximally one month (during the Ramadan period, due to limited forces). The area is grazed from the higher zone (around 2000m) to the lower zone (around 1600m) twice per season, in a sort of circle. Every day the herder starts in another direction from his tent and leads the animals to the pastures, once in the morning and once in the evening. He passes a stream once (autumn) to twice (summer) a day.

Purpose:
The grass should not get dusty and dirty, explaining why the herder daily changes the pastures, only revisiting the same places every two to three days.

Establishment/ maintenance activities and inputs:
After accompanying his father as a child and a kind of an apprenticeship (of one year) later on, M. is considered by the villagers as a good herder and they give him their animals for herding. But M. applies for land on the forest department only after working as a guardian and as a tractor driver for 20 years. For the herding profession observing the animals precisely is necessary, in order not to lose any of them. And the maintenance of the pastures is guaranteed by the strict rotational scheme.

Natural/ human environment:
The pasture-area is in a generally well-conserved state. Moderate to high values of fractional vegetation cover can be observed and only few signs of recent erosion processes (through water) are visible. The area is characterised by steep slopes where still signs of past tree-planting during the USSR period are visible by some trees, many little platforms made for tree-planting and a few terraced areas. Eventhough, many trees have been grazed and do not stand anymore. Besides steep areas there are small, quite flat areas (where the herder installs his tents), that used to be cultivated (wheat) till 1966. These areas generally have low cover-values and signs of rill-erosion, which the herder attributes to the past tilling activity. However, it might also be the trampling and sitting of the animals (staying near the herder's tent at noon-time and during the night) causing this erosion. Nutrient management is provided for by the dung of the animals which is not collected, contrarily to the pastures near the villages.

Location: Faizabad

Technology area: 3 km²

Conservation measure: - management measure
- management measure

Stage of intervention:
- prevention of land degradation

Origin of technology:
through land user's initiative (traditional), traditional (> 50 years ago)

Land use: Grazing land: extensive grazing

Original land use was 'Forests / woodlands: plantations, afforestation'. Future (final) land use will be 'Grazing land: extensive grazing'.

Climate: - semi-arid
- temperate

WOCAT database reference: QT TAJ2

Related approach:
Seminomadic individual herding

Compiled by: Kasirov Murod, ,

Date: 15.08.2008, updated 25.08.2009 by Christian Wirz

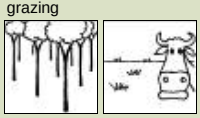
Classification

Land use problems: The trampling of the animals near the tent, the feeding on young trees and the daily passage of the herd of a limited number of streams (eutrophication).

In land users's view: No major land use problems due to good management. Only the first rain that cannot be absorbed by the dry soils is a problem.

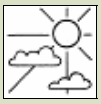
Land Use:

Grazing land: extensive grazing



Original land use was 'Forests / woodlands: plantations, afforestation'. Future (final) land use will be 'Grazing land: extensive grazing'.

Climate:



- semi-arid
- temperate

Degradation:

Conservation measure:

management: (M1) change of land use type, (M4) major change in timing of activities

Stage of intervention:

- [x] Prevention
- [ ] Mitigation/reductior
- [ ] Rehabilitation

Origin:

- [ ] Land user's initiative
- [ ] Experiments/research
- [ ] Externally introduced

Level of technical knowledge:

- [x] Low: field staff / agricultural advisor
- [x] Medium: land user
- [ ] High

Main causes of land degradation:
- overgrazing (Causing Pc, Bc, Wt)
- natural: droughts (Causing Pk, Pc, Ha)

Main technical functions:
- increase of biomass (quantity)
- control of dispersed runoff (retain/trap)

Secondary technical functions:
- palatable fodder
- improvement of ground cover
- control of fires

Environment

Legend: most common / common / less common

Natural Environment

Avg. annual rainfall (mm):

- >5000:
- 4000-5000:
- 3000-4000:
- 2000-3000:
- 1500-2000:
- 1000-1500:
- 750-1000:
- 500-750: [x]
- 250-500:
- <250:

Altitude (m):

- >4000:
- 500-4000:
- 000-3500:
- 500-3000:
- 000-2500:
- 500-2000: [x]
- 000-1500:
- 500-1000:
- 100-500:
- <100:

Slopes:

- flat (0-2%):
- gentle (2-5%):
- moderate (5-8%):
- rolling (8-16%):
- hilly (16-30%): [x]
- steep (30-60%): [x]
- very steep (>60%): [x]

Landforms:

- plateau / plains:
- ridges: [x]
- mountain slopes: [x]
- hill slopes:
- footslopes:
- valley floors:

Soil depth:

- very shallow (0-20cm):
- shallow (20-50cm): [x]
- moderately deep (50-80c
- deep (80-120cm):
- very deep (>120cm):

Soil fertility:

- very high:
- high:
- medium:
- low: [x]
- very low:

Soil texture:

- coarse (sandy):
- medium (loam): [x]
- fine (clay):

Topsoil organic matter:

- high (> 3%):
- medium (1-3%):
- low (<1%): [x]

Soil drainage:

- good: [x]
- medium:
- poor:

Growing season(s): 270 days (Oct to Jun)

Soil water storage capacity: medium

Ground water table:

Availability of surface water: poor / none

Water quality: for agricultural us

Biodiversity:

Human environment

Size of land per household (ha):

grazin land:

Land user: individual / household, small scale land users, common / average land users, mainly men. Herding is considered as a male profession, inherited from father to son. In nomadic peoples the whole families are mobile and women are responsible for domestic work.

Population density: <10 persons/km2

Importance of off-farm income:
< 10% of all income. The herder claims to nourish himself and his wife with the income from herding. But, once he willl not be able to work as a herder anymore, he might depend on off-farm income from his children (remittances)

Access to service/ infrastructure:
Low: all.

< 1 ha: ☐
1-2 ha: ☐
2-5 ha: ☐
5-15 ha: ☐
15-50 ha: ☐
50-100 ha:
100-500 ha:
500-1000 ha:
1,000-10,000 h
10,000-100,00(
>100,000 ha:

Annual population growth: 1–2 %

Land ownership: state

Land/water use rights: leased

Water: communal (organized)

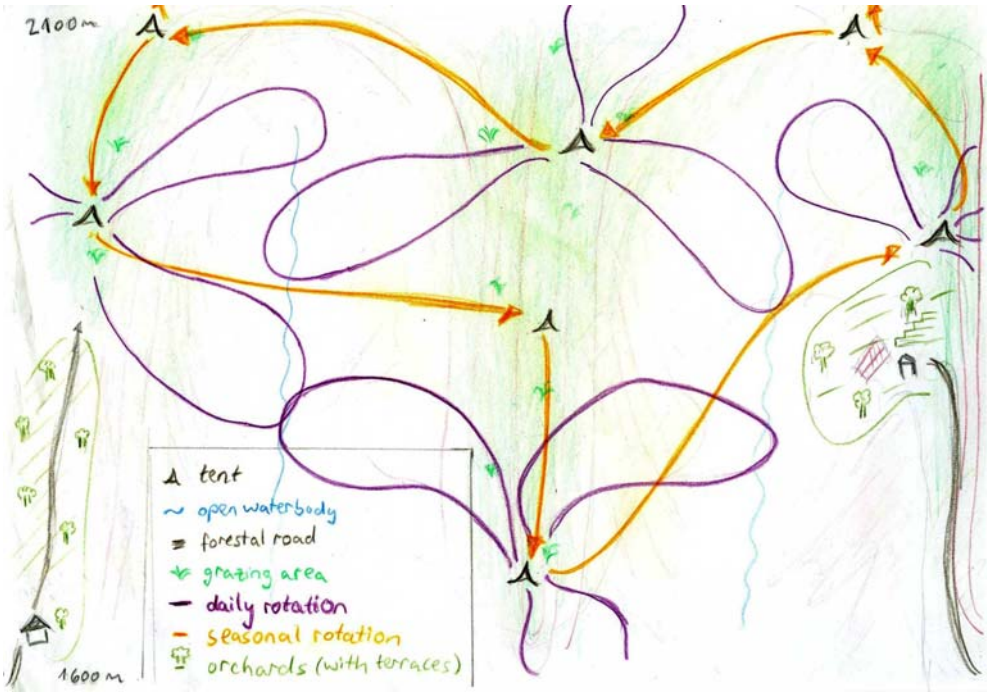
Relative level of wealth: rich (100% of land users)

Market orientation:

Grazing land: mainly mixed (subistence/commercial),

Mechanisation:

Daily and seasonal rotation. (Christian Wirz, Switzerland)



Implementation activities, inputs and costs

Establishment activities for management measures:

activity:	equipment:	timing:
Buying a herd		constantly investing

Maintenance activities for management measures:

activity:	equipment:	timing:
Rent fee for land of forest department		once per year
Salary of an assistant herder (normally, but not in 2008)		at the end of the season
compensation for dead animals		at the end of the season
Animal medecine		if necessary
Salt		daily

FINANCES

Cost details:

		Establishment costs (per ha):			*Recurrent costs (per ha):*		
Category:	*Input:*	*Quantity:*	*US$ Equiv.:*	*% borne by land user:*	*Quantity:*	*US$ Equiv.:*	*% borne by land user:*
total				100			100

Duration of establishment phase: 12 months

Assessment

Production and socio-economic benefits

+ + +	increased animal production
+ + +	increased fodder quality
+ +	increased fodder production
+	increased water availability / quality for livestock

Production and socio-economic disadvantages

- -	reduced wood production

Socio-cultural benefits

+ +	improved food security / self-sufficiency (reduced dependence on ext. support)

Socio-cultural disadvantages

- -	loss of recreational opportunities
-	increased health problems

Ecological benefits

+ +	improved soil cover
+	increased plant diversity

Ecological disadvantages

Off-site benefits

Off-site disadvantages

Contribution to human well-being/livelihoods

Benefits/costs according to land user:	short-term:	long-term:
Benefits compared with investment costs:	neutral / balanced	very positive
Benefits compared with maintenance costs:	slightly positive	positive

Concluding statements

Strengths and -> how to sustain/improve

Form of land use making it possible to take some pressure from the common pastures without great damages. -> It needs to be assured that also poorer families, who depend even more on livestock breeding than richer ones, can give their animals to M. or other professional herders. This could be realised by engaging herder assistants from poor families

The rotational scheme is much more elaborated than in the case of the villages' pastures, which can be explained by more land available -> Land users like M. should be addressed by forest administration to elaborate legal forms of herding with little damages on natural resources on this land. This will probably require land reforms.

Grazing stabilises the soils and is thus a prevention against gully erosion in areas with low cover (former cropland). Animals have the same effect as the terraces built years ago. -> Grazing activity should continue, once M. is too old for working.

The animals provide for soil fertility by their dung, instead of the fertilisers used in Soviet times. This positively influences the share of palatable plants and cover in general and, by this, soil moisture.

The area on the forest department is a good alternative to the much too small pasture-area near the village

For further information consult WOCAT database (www.wocat.net)!

Weaknesses and -> how to overcome

The main problem of this form of grazing is that it doesn't allow the regrowth of trees. -> Changing the areas use for grazing, respectively haymaking, every few years.

Cover is markedly reduced around the places where tents are installed. -> By changing the camping place (but: limited flat areas!) or not keeping the animals in the same place at noon time and during night time, these areas might recover.

Tree planting is not possible as long as the area is used for grazing. -> By giving people land for longer periods (than one year) and with more freedoms in its use, people would gain interest in diversifying use: They would split up "their" land into haymaking, orchard and pasture areas.

Herders on the way back to southern Tajikistan with their herd. (Christian Wirz, Switzerland)

The herder gathering his animals after the noon-time rest. (Christian Wirz, Switzerland)

Seminomadic individual herding

Tajikistan - Chupon / Dajmardei Khaspi (professional herding)

Pasture management by a single herder, assisted either by an employee or by his own grandchildren, in collaboration with the habitants of the nearby village Karsang.

Aims / objectives:
The herder chooses his territory by the criteria of biomass, vegetation cover and availability of surface water. In his work he gives special attention to fattening the animals, to not losing any of them and to giving back the right animals to the right tenant at the end of the season. For him it is important to be sincere with the tenants and to pay for lost animals.

Methods:
Every method applied serves the target of having an obeying herd. The herder works with lots of patience. In the first two weeks he pays very much attention to keeping the herd together, so the animals get used to each other. The rotational grazing scheme also fulfills the requirement of fattening the animals. Grazing the animals by night-time is a method to make the animals obey better. Part of the work is the daily control of the herd to identify sick animals and treat them.The animals are by the way not led by the herder, but rather accompanied by him.

Stages of implementation:
After apprenticeship the herder is entrusted with animals from the village and with the generated income can then gradually build up his own herd.

Role of stakeholder:
The herder is responsible for the relation with his animals, with the villagers and with the forest department (contract).

Location: Faizabad

Approach area: 3 km²

Land use type:

Type of approach:
traditional/indigenous (1987

Focus: mainly on other activities

Climate:

WOCAT database reference: QA TAJ2

Related technology (ies):
- Daily and seasonal rotation on grassland

Compiled by: Kasirov Murod, ,

Date: 15.08.2008, updated 25.08.2009 by Christian Wirz

Problem, objectives and constraints

Problems

The inhabitants of the village give the herder their animals because they know that the animals will be more healthy on the more natural pastures frequented by him compared with village pastures and because the animals get more reserves for winter-time. The herder claims that the animals need 50% less hay and fodder in winter than the animals grazed near the villages.

Aims/Objectives

The herder's motivation to continue his father's work was that it enabled him to nourish his family. In his work he pays attention to fatten the animals enough to make them survive winter and to give them all back.

Constraints addressed

Major	Constraint	Treatment
other	For M. the principal problem are bears (and wolves) killing animals.	Since he is not allowed to have a rifle to kill wild animals he has to chase them away with his dogs. This means that in summer, when the bears descend to lower areas for fruit in the orchards, he often has to keep awake by night.

Minor	Constraint	Treatment
institutional	It is necessary to have good relations to obtain land from the forest administration.	As M. worked for the forest department for many years, it was not a problem for him to lease land.
financial	Paying for lost animals.	As long as the herder can find the lost animal, even if it is dead, he will not have to pay for it.
social / cultural / religious	Being unable to go to parties and weddings.	As it is not a problem for the herder (but perhaps for his wife and family?) the problem is not tackled.

Participation and decision making

Target groups

land user

Approach costs met by:

local community / land user(s)	100 %
	%
TOTAL	100 %
Annual budget for SLM component:	<2,000

Decisions on choice of the Technology (ies): by land users alone (self-initiative / bottom-up)
The herder learnt his profession during an apprenticeship of one year.

Decisions on method of implementing the Technology (ies): by land users alone (self-initiative / bottom-up)
M. learned all the technologies from his father, but says, that he only does his job half as well as his father.

Approach designed by: - land users

Implementing bodies: local community / land user(s) The herder himself implements the approach.

Land user involvement

Phase	Involvement	Activities
Initiation/motivation	self-mobilization	Deciding to be a herder
Planning	none	
Implementation	self-mobilization	Once M. knew how to treat the animals he could begin work with an own herd.
Monitoring/evaluation	none	
Research	none	

Differences between participation of men and women: yes, greatly. Because herding is considered to be a work for women

Involvement of disadvantaged groups: no.

Technical support

Training / awareness raising: yes, for field staff/agricultural advisor. Young men and boys.

Teaching of herding method: He tells his assistants not to beat the animals, not to shout at them, to treat animals fairly so they obey and to nourish them sufficiently so they don't walk away by night.

Training provided for land users was in the form of on-the-job.

Advisory service:

Key elements: (1.) (2.) (3.)

Research: Was research part of the approach? no

External material support / subsidies

Contribution per area (state/private sector): No.

Labour: Labour input by land users was mainly paid in cash, mainly food-for-work. Whereas his grandsons help him and get food therefore, the herder sometimes employs assistants who are paid.

Inputs provided:

Credit provided: no

Support to local institutions:

Monitoring and evaluation

Monitored aspects	Methods and indicators
- none	:

Changes as result of monitoring and evaluation:
no -

Impacts of the Approach

Improved sustainable land management: yes, little - More biodiversity, less fertility decline, less cover reduction (compared to the grazing method used near the villages)

Adoption by other land users / projects: yes, few - Young men herding in Faizabad area, one of them only a few ridges in the east of M.

Improved livelihoods / human well-being: yes, moderately - Whereas in the villages every family has to send someone as a herder once per month, M. earns money for his job and breeds his own animals. On the other hand the family structure is disrupted by the constant absence of M.

Improved situation of disadvantaged groups: no -

Poverty alleviation: yes, little - In finacial terms, it did (by generating income), But in terms of education, it did not help.

Training, advisory service and research:

Training: land users — fair — None of his sons decided to live as a herder. Instead two of his apprentices are now working as herders and making a living as a herder.

Advisory service:

Research:

Land/water use rights:

Help/hinder approach implementation: neither - If tenure were more secure and land use free, M. would divide the rented land into pasture zone, orchard and cropland. This would ensure more self-sufficiency, but probably less income, because he could keep less animals on the reduced pasture area.

Approach reduced problem: -

Overcome problem in future: -

Long-term impact of subsidies:

Concluding statements

Main motivation of land users to implement SLM:

Sustainability of activities: yes — The herder intends to continue his work as long as physically possible. He though wants to take less animals in the following year and instead more cows and less sheep and goats. He says that cows are easier to keep and in addition, he is paid four times more for a cow than for a sheep or a goat.

Concluding statements

Strengths and -> how to sustain/improve

With around 600-700$ per season, the work as a professional herder is quite well-paid (for rural areas). -> As soon as work in the foreigner (especially Russia) becomes scarce, herding will be more attractive again.

For people with a tight relationship to nature and god (in the case of M.) this area is a good place, since remote. -> There will probably continue to be religious, nature-bound young people.

Each tenant has animals with their own comportment. M. only has to deal with a little number of tenants (and thus animal comportments), whereas the village herds are composed by animals of much more tenants.

The herd's composition stays for the whole season, so animals can get used to each other. The composition of the big village herd is not always the same.

The herder is always the same and treats the animals fairly: he leads the animals slowly and doesn't shout at them or beat them.

Weaknesses and -> how to overcome

The way of living is not modern in the young peoples' eyes: They prefer social and urban to rural, solitary life. -> As long as poverty predominates in the villages and cities cannot offer enough jobs to young people, agriculture and herding will stay interesting. Though, new (old) forms of herding might appear, such as herding in groups.

Night grazing makes sheep eat impalatable (poisonous) plants and than become sick (according to a specialist from CARITAS). -> Training and workshops could be a platform for the discussion of such critical aspects.

The trees damaged by the animals are a problem from the herder's point of view. -> He sees the main problem in the past civil war, when lots of trees were chopped illegally. He says that tree-planting would not be a solution, because then grazing would not be possible anymore either.

For further information consult WOCAT database (www.wocat.net)!

Combination of fruit-production and haymaking. (Christian Wirz, Switzerland)

Apple trees as a protection against wind. (Christian Wirz, Switzerland)

Combined cut-and-carry and fruit-production system with terraces

Tajikistan Зина бох (tajik for terrace garden)

A combination of fruit- and nut-trees together with seminatural trees and shrubs on one side with grass-communities on the other side provide for a diversified production system.

Description:
Fruit- and nut-trees give the production system the characteristics of an orchard, whereas sour cherry trees rather provide for a jungle atmosphere. They spread very quickly once they are planted. Hayproduction substitutes other uses of the lowest vegetation layer, since grazing is forbidden. The whole territory is concipied as a research station.

Purpose:
In general trees act against erosion: By their stabilising function they prevent soil from being washed out. Especially nut-trees with their 20 to 25 m long roots preserve soil moisture and by that consolidate soil structure. Terraces contribute to this moisture-preserving and production-enhancing function. They are very important in order to make rather steep land exploitable by reducing slope. Haymaking does not damage soils, but is only allowed after the end of June so that grasses can reproduce before.

Establishment / maintenance:
Both the establishment of terraces and the planting of trees on such a big surface are costly in terms of labour and money. Maintenance means taking care of trees, taking measures against diseases and conserving soil fertility. Fertilisers are very costly and therefore dung has been substituting them in the last years.

Natural / human environment:
From the two research stations of the orchard institute - one in the upper hill-zone and one close to the village Karsang - only the second one is assessed. This area is surrounded by two rivers in the West and in the East, with its main exposition to the South. It is in direct competition for irrigation water, especially needed for the trees, with the village. The orchard is situated on a ridge that is in the haymaking area, but is accessible for animals from the village.

Location: Faizabad

Technology area: 0.7 km²

Conservation measure:
- vegetative measure
- management measure
- structural measure

Stage of intervention:
- prevention of land degradation

Origin of technology:
through experiments / research, 10-50 years ago
externally introduced through project, 10-50 years ago

Land use: Grazing land: intensive grazing / fodder

Climate:
- semi-arid
- subtropics

WOCAT database reference: QT TAJ3

Related approach:
State-controlled research territory for orcharding

Compiled by: Khodirov Higmatullo, Orchard Institute, Tajikistan

Date: 01.08.2008, updated 18.07.2009 by Christian Wirz

Classification

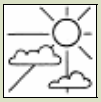
Land use problems: The main problems are arid conditions and the loss of fertility, mainly by processes of water erosion.

In land users's view: Gully erosion by water and wind erosion together with droughts are the main problems. Gullly erosion may also be caused by

Land Use:

Grazing land: intensive grazing / fodder production

Climate:



- semi-arid
- subtropics

Degradation:

Erosion by water: loss of topsoil by water

Erosion by wind: loss of topsoil: uniform displacement

Conservation measure:

vegetative: (V1) tree and shrub cover

management: (M2) change of management / intensity level

Stage of intervention:

- [x] Prevention
- [ ] Mitigation/reductior
- [ ] Rehabilitation

Origin:

- [ ] Land user's initiative
- [x] Experiments/research ; 10-50 years
- [x] Externally introduced ; 10-50 years

Level of technical knowledge:

- [x] Low: land user
- [x] Medium: field staff / agricultural advisor
- [x] High: Research coordinator

Main causes of land degradation:
- natural: droughts (No considerable precipitation for one and a half years. Causing compaction, crusting and aridification.)
- natural: change of seasonal rainfall (According to agronomist and elderly persons steady decrease of rainfall Causing aridification..)

Main technical functions:
- promotion of vegetation species and varieties
- reduction in wind speed
- improvement of water quality, buffering/filtering water
- stabilisation of soil (eg by tree roots against land slides)

Secondary technical functions:
- increase of biomass (quantity)
- sediment rention / trapping, sediment harvesting
- water spreading
- increase of infiltration
- improvement of surface structure (crusting, sealing)
- reduction of slope angle
- trees protect from snow
- control of fires
- increase in organic matter
- water harvesting / increase water supply
- increase in nutrient availability (supply, recycling)
- improvement of subsoil structure (hardpan)
- improvement of topsoil structure (compaction)

Environment

Legend: most common / common / less common

Natural Environment

Avg. annual rainfall (mm):

- >5000:
- 4000-5000:
- 3000-4000:
- 2000-3000:
- 1500-2000:
- 1000-1500:
- 750-1000:
- [x] 500-750:
- 250-500:
- <250:

Altitude (m):

- >4000:
- 500-4000:
- 000-3500:
- 500-3000:
- 000-2500:
- 500-2000:
- [x] 000-1500:
- 500-1000:
- 100-500:
- <100:

Slopes:

- flat (0-2%):
- [x] gentle (2-5%):
- moderate (5-8%):
- rolling (8-16%):
- [x] hilly (16-30%):
- steep (30-60%):
- very steep (>60%):

Landforms:

- plateau / plains:
- [x] ridges:
- mountain slopes:
- [x] hill slopes:
- footslopes:
- valley floors:

Soil depth:

- very shallow (0-20cm):
- [x] shallow (20-50cm):
- moderately deep (50-80c
- deep (80-120cm):
- [x] very deep (>120cm):

Soil fertility:

- very high:
- high:
- medium:
- [x] low:
- very low:

Soil texture:

- coarse (sandy):
- [x] medium (loam):
- fine (clay):

Topsoil organic matter:

- high (> 3%):
- [x] medium (1-3%):
- [x] low (<1%):

Soil drainage:

- [x] good:
- medium:
- poor:

Growing season(s): 270 days (Oct to Jul) **Soil water storage capacity:** medium **Water quality:** good drinking wa

Ground water table: 5 – 50 m **Biodiversity:** high

Availability of surface water: poor / none

Human environment

Size of land per household (ha):

	grazin land:
< 1 ha:	☐
1-2 ha:	☐
2-5 ha:	■
5-15 ha:	■
15-50 ha:	☐
50-100 ha:	☐
100-500 ha:	☐
500-1000 ha:	☐
1,000-10,000 h	☐
10,000-100,00(	☐
>100,000 ha:	☐

Land user: employee (company, government), small scale land users, common / average land users, mixed.

Population density: 50-100 persons/km2

Annual population growth: 1-2 %

Land ownership: state

Land/water use rights: communal (organized)

Water

Whereas land use rights are restricted to those employed by the research institute, water use is negotiated between the research institute and the village authorities.

Relative level of wealth: average (100% of land users)

Importance of off-farm income:

> 50% of all income. Nearly all people have family members (mostly sons) in Russia, who send remittances.

Access to service/ infrastructure:

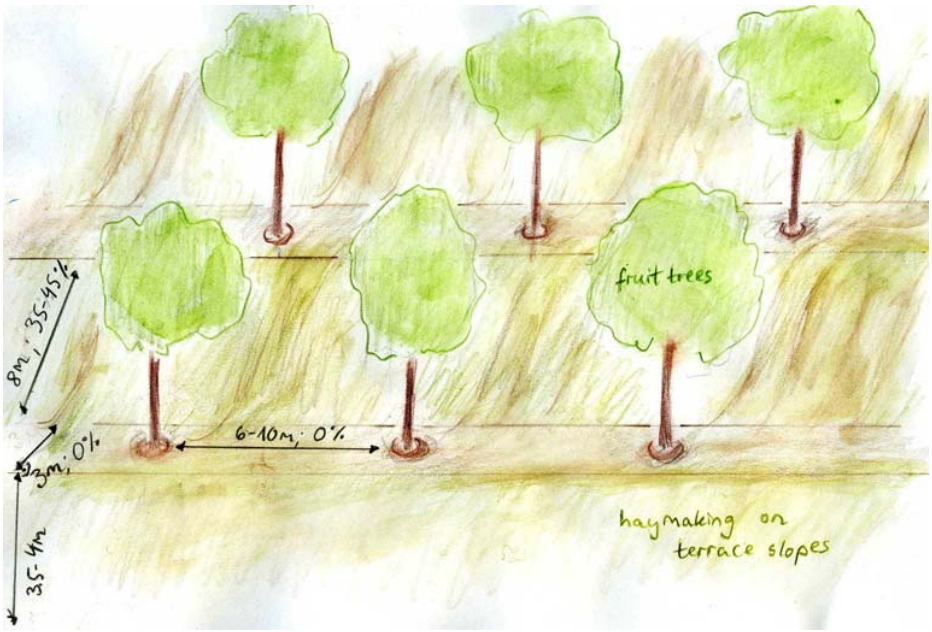
Low: health, employment (eg off-farm), drinking water and sanitation, financial services.

Market orientation:

Grazing land: mainly mixed (subistence/commercial),

Mechanisation:

Terraces with fruit trees. (Christian Wirz, Switzerland)



Implementation activities, inputs and costs

Establishment activities for vegetative measures:

activity:	energy:	equipment:	timing:
Planting of trees with provenance from Russia and Ukraine			Tree plants
Tree-planting, grafting, giving dung			20 persons for 3 years

Maintenance activities for vegetative measures:

activity:	energy:	equipment:	timing:
Yearly replacement of fruit-trees (10-15% per year)			10 persons plus brigadier, always employed
Aerating soils around trees, each spring			10 workers, fix employment
Applying animal dung and / or fertilisers			10 workers, fix employment
Seasonal workers for harvesting			10 workers, additionally
Planning of activities			1 director

Construction activities for structural measures:

activity:	energy:	equipment:	timing:
Terrace establishment			2 tractor drivers for 1 year

Maintenance activities for management measures:

activity:	equipment:	timing:
Haymaking		1 month

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Cost details:

		Establishment costs (per ha):			*Recurrent costs (per ha):*		
Category:	*Input:*	*Quantity:*	*US$ Equiv.:*	*% borne by land user:*	*Quantity:*	*US$ Equiv.:*	*% borne by land user:*
others			614				0
agricultural	seedlings (No.)		100				0
agricultural	fertiliser (kg)					28	0
labour	person days		714			93	0
total			1428			121	0

Duration of establishment phase: 36 months

Assessment

Production and socio-economic benefits					Production and socio-economic disadvantages			
+	+	+	increased fodder production		-	-	-	increased demand for irrigation water
+	+		increased wood production		-	-	-	reduced crop production
+	+		increased farm income					
+	+		increased irrigation water availability / quality					
+	+		increased fodder quality					
+			increased wood production					
Socio-cultural benefits					**Socio-cultural disadvantages**			
+	+		improved food security / self-sufficiency (reduced dependence on ext. support)		-	-		socio-cultural conflicts
+			improved health					
Ecological benefits					**Ecological disadvantages**			
+	+	+	increased plant diversity		-	-		increased fire risk
+	+	+	reduced wind velocity		-			increased salinity
+	+	+	increased soil organic matter / below ground C					
+	+	+	increased soil moisture					
+	+	+	reduced soil loss					
+	+		reduced surface runoff					
+	+		improved soil cover					
+			reduced soil crusting/sealing					
Off-site benefits					**Off-site disadvantages**			
+			reduced wind transported sediments					

Contribution to human well-being/livelihoods

Benefits/costs according to land user:	short-term:	long-term:
Benefits compared with investment costs:		
Benefits compared with maintenance costs:		

Concluding statements

Strengths and -> how to sustain/improve

Weaknesses and -> how to overcome

For further information consult WOCAT database (www.wocat.net)!

Haymaking on the research territory. (Christian Wirz, Switzerland)

Explanations about rehabilitation of landslide areas by tree planting. (Christian Wirz, Switzerland)

State-controlled research territory for orcharding

Tajikistan – Зоналная опытная станция (ЗОС)

Cultivation of an orchard with research activities and research staff with food for work.

Aims / objectives:
The main objective is to dispose of varieties of fruits that are adapted to different conditions. Another objective is to prevent degradation and test methods of rehabilitation and to spread this knowledge. The orchard was also implemented as a source of labour for 50 employees. In the last years it has become more important to acquire self-sufficiency by fruit- and hay-production, because wages cannot always be paid. And because of limited state-support in terms of fertilisers, pesticides and machines, the selling of tree saplings is important.

Methods used:
Work is subdivided into research, whereby the analysis of soils is carried out in laboratories, into conservation methods carried out by field staff and the brigadier himself (planting fruit and other trees, grafting fruit trees, planting and maintaining tree saplings, combatting pests and forbs) and harvest (of fruits and hay) that is carried out by all the employees and their families. The fruits are partly dried and sold.

Stages of implementation:
After the terraces being built and the trees being planted in the early 1960ies, the orchard needed to be maintained: e.g. annually trees are substituted and fertilisers, manure and pesticides are applied. When trees are not grown, intercropping is possible. Since 1992 soils on the terraces, between the trees, are not tilled anymore, because rees are too high.

Role of participants:
The workers are initially employed for a clearly defined work such as tractor driver, research coordinator or research scientist. They execute orders given by their superiors. In the years after independance the strict subdivision is broken up and the research station is more independent. During civil war, when the district government was nearly inexistant, the land needed to be distributed among the employees, who were now land rentors and had to maintain their part of the orchard by themselves: It was the only way to protect the orchard from being destroyed, says the research coordinator.

Location: Faizobod

Approach area: 0.7 km²

Land use type:

Type of approach:
project/programme based (1965

Focus: mainly on conservation with othe

Climate:

WOCAT database reference: QA TAJ3

Related technology (ies):
- Combined cut-and-carry and fruit-production system

Compiled by: Khodirov Higmatullo, Orchard institute of Tajikistan, Tajikistan

Date: 01.08.2008, updated 18.07.2009 by Christian Wirz

Problem, objectives and constraints

Problems

The main focus was research on the productivity and stress-resistance (e.g. droughts) of different varieties of fruit-trees and vines under different climatic conditions. Another important objective is the elaboration of efficient terrace technology against erosion.There were also particular interests of political leaders such as vineyards for wine-production, a factor that is not important anymore in a country where the Islamic religion seems to be more important today than in Soviet times.

Aims/Objectives

The field station should elaborate knowledge on fruit-production in steep areas. The knowledge gained on terraces would also be useful in the 1970ies, when forest administration was implemented and started to adopt and adapt the terrace technology. Research was in cooperation with other regions of Tajikistan and the URSS, e.g. good walnut varieties from Ukraine were imported and bred to make them adapted to local climate. From the very beginning it was important integrate and to create a surplus value for local population, be it jobs or knowledge on erosion prevention and fruit-production.
In the last years it has become more important to spread conservation and production knowledge in favour of local population: Workshops are regularly organised, together with NGOs and with the own specialists, to make population share the gained knowlegde and apply it in their own orchards.

Constraints addressed

Minor	Constraint	Treatment
technical	Topography (very steep slopes) difficult for mechanical use and dangerous for tractor drivers.	Terraces reduce slope and besides being a better wind-protection planting the trees diagonally to the main slope direction is a protection for tractor drivers (if they overturn).

Participation and decision making

Target groups

SLM specialists, agricultural advisor

Politicians, decision makers

Approach costs met by:

government	100 %
TOTAL	100 %

Annual budget for SLM component:

Decisions on choice of the Technology (ies): by SLM specialists alone (top-down)
Different experts are the decision-makers, depending on the problem (e.g. type of fruits). This has stayed till today.

Decisions on method of implementing the Technology (ies): by SLM specialists alone (top-down)

Approach designed by: - national specialists

Implementing bodies: government

According to national and Soviet agricultural policies, the orchard was designed and organised. It was the Academy of Sciences to take the decision of implementing this technology.

Land user involvement

Phase	Involvement	Activities
Initiation/motivation	none	
Planning	none	
Implementation	passive	Tractor-driver for terraces and field staff for tree-planting, land users' families for harvesting.
Monitoring/evaluation	none	
Research	passive	

Differences between participation of men and women: yes, moderately. Women are considered to be responsible for work in the household, even if they are sometimes the main field-workers today. No women are found in a leading position of this research station.

Involvement of disadvantaged groups: no.

Technical support

Training / awareness raising: yes, for land user, field staff/agricultural advisor

For land users it is interesting to learn specific technologies in fruit-production, e.g. how walnut saplings are maintained. For field staff it is interesting to learn from specialists how something is explained to different participants (young, old).

Training provided for land users was in the form of demonstration areas.

Advisory service:

Key elements: (1.) (2.) (3.)

Research: Was research part of the approach?

External material support / subsidies

Contribution per area (state/private sector): No.

Labour: Labour input by land users was mainly food-for-work, partially paid in cash. There are fix employees with monthly salaries. But often, instead of salaries, people are paid in kind (i.e. the fruits for own use are substracted from the salary).

Inputs provided: seedlings were , fertiliser were , biocides were , machinery (tractors.) were under the approach. The government paid the whole implementation of the technology.

Credit provided:

Support to local institutions:

Monitoring and evaluation

Monitored aspects	Methods and indicators
- bio-physical	Regular observations by project staff: Stress-resistance, depending on climate
- economic / production	measurements by project staff: Fruit harvest per tree.

Changes as result of monitoring and evaluation:
-

Impacts of the Approach

Improved sustainable land management: yes, little - Cover recovered on a nearby ex-cropland area, where the orchard technology was applied. It is especially the grazing-stop that triggered the change.

Adoption by other land users / projects: yes, some - In the 1970s the forest department began with state-organised reforesting and terracing. Nowadays land users visiting workshops in the research station adopt the orchard technology, but just for self-sufficiency.

Improved livelihoods / human well-being: yes, moderately - Especially the employees could profit from their job, be it by payments in kind or by the wages. During civil war the decision to leave the cultivation of the orchards to local land users did not only help them survive and maintain the orchard, but also helped them organise themselves.

Improved situation of disadvantaged groups: -

Poverty alleviation: yes, little - The salaries allowed some land users to buy private livestock.

Training, advisory service and research:

Training:

Advisory service:

Research:

Land/water use rights:

Help/hinder approach implementation: help: greatly - Land belonged to the state in former USSR and the state initiated the project.

Approach reduced problem: -

Overcome problem in future: -

Long-term impact of subsidies: Without subsidies no research would be possible (anymore).

Concluding statements

Main motivation of land users to implement SLM:

Sustainability of activities: uncertain Already today organisations carrying out workshops or training activities are asked to pay for it: food, paper and pens for the participants have to be organised.

Concluding statements

Strengths and -> how to sustain/improve	Weaknesses and -> how to overcome
It helps spread knowledge on an efficient conservation technology, especially on tree planting. It permits land users to learn conservation methods and to make their living at the same time. -> Giving the land users more decision capacities might strengthen their will to implement conservation.	Research activities and the improvement of conservation technologies depend very much on the research coordinator. -> Strengthening the position of land users would help make the system more sustainable on the long-term.
The strong focus on research helps improve the orchard. -> Inputs from external experts (from Switzerland) could help improve the technology.	The chaos of war could have destroyed the orchard (people chopping trees illegally in a situation of no control). -> The possibility of employees to rent land (land tenure assured) was the only possibility to save the orchard (as soon as the harvest goes to the land user, he has more interest to improve the land use).

For further information consult WOCAT database (www.wocat.net)!