Sustainable Land Management by Disaster Risk Reduction in Muminabad district, Tajikistan, using WOCAT methods

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Cover photo: Orchard, wheat crop and pasture in the Obishur watershed (M. Conder 2012)

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ABBREVIATIONS AND ACRONYMS

ARC	Antecedent runoff condition
a.s.l.	above sea level
CBA	Cost-Benefit Analysis
CDE	Centre for Development and Environment, University of Berne
Ch	Chukurak Watershed
cm	Centimetres
CN	Curve Number
CP	Common Practice
DESIRE	Desertification Mitigation and Remediation of land
DRR	Disaster Risk Reduction
DPSIR	Driver-Pressure-State-Impact-Response
EC	Establishment Costs
HFA	Hyogo Framework for Action
ha	Hectare(s)
HSG	Hydrologic Soil Group
IWSM	Integrated Watershed Management
kg	Kilogram
LDC	Local Development Committee Muminabad
LDM	Local Development Muminbad (programme of Caritas Switzerland)
MC	Maintenance Costs
mm	Millimetre
Ob	Obishur watershed
Q	Runoff
QT	Technology questionnaire by WOCAT
SDC	Swiss Agency for Development and Cooperation
SMART	Specific, Measurable, Attainable, Realistic and Time bound indicators
SOC	Soil Organic Carbon
SLM	Sustainable Land Management
STC	Sudsidized Total Costs
SWC	Soil and Water Conservation
TC	Total Costs
TJS	Tajik Somoni
US$	US Dollars
USDA SCS	United States Department for Agriculture Soil Conservation Service
VSA	Visual Soil Assessment
WOCAT	World Overview of Conservation Approaches and Technologies

ABSTRACT

The study was conducted in the frame of the Integrated Watershed Management Initiative of the Swiss Agency for Development and Cooperation SDC and the watershed management project implemented by Caritas Switzerland in Muminabad, Tajikistan. It assesses the impact of sustainable land management (SLM) on disaster risk reduction (DRR) in two small watersheds in Muminabad District, Tajikistan.

Continuing land degradation can be observed globally. Simultaneously, the number of disasters and people impacted are increasing worldwide. Degraded soils have reduced water infiltration capacity and soil cohesion, leading to increased runoff generation and soil loss as a result of erosion processes. Excessive runoff may be source of disasters. Together with the heavy weather events due to climate change disaster frequency and its impact increase. The rural population is particularly concerned because of their direct dependence on natural resources and exposure to disasters. For most of the rural population in Muminabad, agriculture is the main source of income. The ongoing land degradation endangers livelihoods and contributes to an increased frequency and impact of disasters, as floods and mudflows through excessive runoff.

In order to reduce disaster risk and to guarantee soils' productivity, a sustainable use of land is crucial. SLM technologies offer alternatives to the improper land use and depletion of natural resources. To further spread SLM, disseminating knowledge of practices and their multiple benefits among stakeholders is crucial.

However, good management practices and innovative farming systems are rare in Muminabad. Little quantitative information is available about the benefits regarding disaster risk reduction and livelihood impacts of SLM technologies.

The overall objective of the study consists of the assessment of both the cost and the on- and off-site benefits of implementing SLM technologies in the watersheds of Muminabad. The study area focuses on the middle zone where runoff contributions are important and it is part of upstream and downstream processes in the watersheds. With the aim of disaster risk reduction, the study develops scenarios of potential runoff reduction at watershed level.

Field work was carried out between July and September 2012 in the watersheds of Obishur and Chukurak, Muminabad district. Six study plots of a common practice (CP) and of a nearby SLM technology were selected, building six comparative studies. This included two plots each for the main land use types (pasture, orchard, and cropland) per watershed. In each plot, land user interviews, soil sampling and a visual field assessment were conducted. For the cost-benefit analysis (CBA), costs of each case study were assessed with the Technology Questionnaire (QT) provided by the World Overview of Conservation Approaches and Technologies (WOCAT). The benefits, consisting of productivity, soil quality and runoff reduction, were quantified by a yield questionnaire, determination of the soil organic carbon (SOC) content, and the runoff Curve Number (CN) model by US Department of Agriculture (USDA). Additionally, land use related benefits were documented using the QT supported by a visual field assessment of soil quality. The benefits quantified by different methods were finally compared by means of triangulation, visualized by spider webs. Runoff scenarios depending on area percentage covered by SLM technologies were developed for the three land use types of the middle zone of the watershed.

Results showed that costs and yield vary greatly between study plots and depending on the time since SLM implementation. The net profit, resulting from cost and yield calculations, depends primarily on the land use type. The high establishment costs for orchards and perennial crops (SLM cropland) are unprofitable in the short-term. In the long-term net profitability depends on land use practices. On average, SLM technologies showed a net profit that was three times higher than CPs.

Soil quality represented by SOC ranged from 0.81 to 1.75 % with an average content of 1.09 % for a depth of 50 cm. SLM technologies showed higher SOC than CP, except in orchards. Runoff by CN was calculated assuming a storm event with a precipitation rate of 85mm for all calculations. Average runoff from SLM technologies was lower by one fourth in comparison to CPs. Depending on the land use type, runoff can be reduced by up to 44% by implementing SLM technologies. The highest potential for runoff reduction showed the conversion of pastures by implementing improved pasture management as in Chukurak and the orchard plots in both watersheds. The assessment of benefits and disadvantages by QT, pointed out that SLM technologies are more beneficial than the corresponding CP, especially in terms of productivity. The visual field assessment indicated that most of the SLM technologies resulted to be low and medium degraded, whereas all CPs and few SLM technologies were heavily degraded.

The qualitative synthesis by spiderwebs underlined that the most important benefit of implementing SLM technologies is runoff reduction (in comparison to productivity and soil quality). A notable increase in productivity is expected by an implementation of SLM technologies. However this increase also depends on the land use type. Generally, SOC content is ranked slightly higher in SLM technologies than in CP.

Different stages of land use improvement by SLM were assumed for the runoff volume scenarios. Scenarios varied from no implementation up to the implementation of SLM technologies on the total area in the middle zone of the watersheds. In a best case scenario, with all three land use types being converted into SLM technologies, a maximum runoff reduction of 21 % and 29 % was estimated for the Obishur and Chukurak watersheds. The maximum runoff reduction volume of the watersheds, 265’000 m^3 and 201’000 m^3 for Obishur and Chukurak respectively, is similar even though the area of the Obishur watershed is twice as high as Chukurak. Croplands show the highest runoff reduction potential in the Obishur watersheds. As croplands are widespread in the middle zone of the Obishur watershed a maximum volume of nearly 180’000 m^3 can be reduced, contributing to 66 % to the total maximum runoff reduction (best case). An implementation of SLM technologies on croplands has consequently the biggest potential for runoff reduction. In the Chukurak watershed pastures show the highest runoff reduction volume in the best case scenario with over 150’000 m^3. With an area of 1000 ha in the middle zone, implementation of SLM technologies on pastures contributes to 77 % of the total maximum runoff reduction (best case). SLM measures on orchards and SLM measures on croplands reduce runoff by a much lesser quantity in Chukurak (15.9 % and 7.6 % respectively).

Overall it can be stated, that SLM technologies lead to higher productivity and better soil quality as indicated by higher SOC than CPs. Runoff volume generated in each plot is conditioned by improved land use practices. Particularly, pasture improvement do not require high expenses and labour inputs, but show a great potential for runoff reduction. Implementation of SLM practices in orchards and to a lesser degree on croplands include high initial costs, but are more productive and beneficial in the long-term. Even though SLM measures are predicted to reduce run-off only by a maximum of 29%, their implementation should be scaled up. Although natural hazard still will occur in the future the overall expected benefits in terms of productivity, soil conservation and runoff reduction shows their potential to contribute to improved livelihoods over the long-term.

Considering the increase of land degradation and of the vulnerability of rural societies, agricultural advisory support should be foremost enhanced among farmers. Participation and knowledge for and by farmers in decision-making is crucial for a sustainable livelihood. The implementation of SLM technology bears high establishment costs and might not manifest the expected benefits in the short-term. In contrast, the SLM technologies are better in terms of the ecological aspects and increase field productivity in the long-term. Poor farmers are constrained by those indicators. For a successful implementation of SLM technologies in Muminabad, incentives and knowledge transfer to farmers must be established.

1 RESEARCH OBJECTIVES AND QUESTIONS

1.1 Problem statement

Agriculture is the basic source of livelihood. The rural population in developing countries is especially highly dependent on agriculture which provides basic commodities (Corvalan et al., 2005). Globally, 80 % of the population live in rural areas, whereof 95 % work in agriculture (WFO, 2012).

This direct dependence on natural resources and the lack of alternative income sources makes subsistent farmers particularly vulnerable to food insecurity and poverty (Chabot and Tondel, 2011; IAASTD, 2013). Poor farmers must profit immediately from their crops, without considering any negative impacts in the long-term. The resulting unsustainable practices lead to an overexploitation of natural resources endangering human well-being (Corvalan et al., 2005).

Land depletion decreases soil cohesion and infiltration capacity, resulting in a high susceptibility to erosion and runoff. Excessive runoff and sediment transport increases vulnerability and the number of disasters on a global level (UNISDR, 2007; Lehmann et al., 2008). Again, poor communities are particularly at risk, due to a high exposure and low resilience against disasters.

Food insecurity as well as the proneness and unpreparedness towards hazards are the greatest threats to the rural community in Muminabad, Tajikistan. Over 50 % of the active population works in agriculture, mainly in (near) self-sufficient farming (Local Development Committee Muminabad LDC and Caritas Switzerland LDM, 2006). Unsustainable land use is widespread and characterized by mono-cropping on steep slopes, vertical ploughing, deforestation and overgrazing. Additionally, short-term land user contracts and small farming plots do not encourage sustainable land use practices. Improper land use results in reduced vegetation cover and nutrient availability in soil compaction and in the destabilization of soil, which in turn is affecting productivity. Poor soil properties enhance the generation of runoff and water related hazards (Kosmas et al., 1997; Lal, 1997). Muminabad is a very disaster prone area and has to deal with hazards on a regular basis. Extreme climate events are predicted to increase in Central Asia, which may raise the frequency of hazards (UNISDR, 2010, Lioumbitseva et al., 2005).

Besides climatic factors, the influence of land use practices on runoff generation is known, although data from the study area is very limited. Overall, disaster risk reduction (DRR) is primordial to secure livelihood and an integral part in local development programs in Muminabad (UNISDR, 2007).

In order to enhance the well-being of rural people land degradation must be overcome with low-input conservation measures (IAASTD, 2013). Sustainable land management (SLM) offers solutions to deal with the vicious cycle of food insecurity and land degradation. SLM has beneficial effects on ecologic and socioeconomic assets, in the short- and long-term and for various stakeholders. The appropriate use of resources raises productivity and hence ensures the livelihoods of rural people. Thereby, a healthy state of soil raises nutrient availability and water storage capacity. High infiltration and low runoff rates support decreasing the intensity and the frequency of disasters.

It is commonly known that land use changes have an influence on productivity and runoff (Ayed and Mohammad, 2010). SLM technologies aim to empower traditional and innovative land use practices in order to prevent and reduce land degradation (Liniger et al., 2008). Innovative farmers with sustainable land use practices can be found in the district of Muminabad, but they are sparse. The adoption of successful practices remains limited.

Even though, SLM technologies generate manifold benefits, little is known about the effectiveness and potential of runoff reduction at plot level. A cost-benefit analysis (CBA) of the plots was carried out with the objective of land use improvement by SLM. The determination and comparison of the costs and of the on- and off-site benefits of different land uses will contribute to decision-making and the implementation of SLM.

1.2 Research Objectives

The overall goal of the study is to assess on- and off-site impacts of SLM technologies in relation to costs and with a special focus on DRR at plot level and the transfer zone or middle zone respectively of the watersheds. The following specific objectives were formulated:

- Assessing costs and benefits of SLM technologies compared to CPs for the three major land use types (rainfed cropland, orchards and pastures) with a focus on net profit and the on- and off-site benefits.
- Cost-benefit analysis and comparison between land use practices from a short- and a long- term perspective.
- Development of runoff reduction scenarios for DRR in the middle zone of the studied watersheds.

The CBA and scenario building using the selected land use practices aim to evaluate the multiple potential of introducing land use improvements. The analysis output aims to raise awareness and encourage the implementation of projects targeting local farmers and rural communities. It also aims to explain reasons for the adoption and non-adoption of SLM in the study area. Finally, the study aims to critically review limits and potentials of the applied research methods.

1.3 Research Questions

The main objectives of the study derive following research questions:

- What on- and off-site impacts can be observed after implementation of SLM practices?
- What is the cost-benefit ratio of runoff reducing land use practices taking into account short- and long-term perspectives?
- What are scenarios for runoff reduction at watershed scale determined by implementing SLM technologies in the middle zone of watersheds?

1.4 Thesis Structure

The structure of the thesis is divided in seven chapters. First the problem, objectives and questions of the study are formulated. This is followed by the description of the socioeconomic and biophysical background and the institutional framework. The third chapter portrays the state of the art of the main drivers for disasters in Muminabad. The forth chapter describes conceptual approaches which were used for the study. The methods figure in the fifth chapter, followed by the results and discussion including the scenario building. The conclusions finalize the thesis.

2 INTRODUCTION

2.1 Background

Tajikistan

Tajikistan is a landlocked and mountainous country, where over fifty percent is located above 3000 m a.s.l. (FAO and Ministry of Agriculture, 2011). The continental climate in Tajikistan is characterized by warm and dry summer and cold and humid winter seasons respectively (Sosin, 2012).

Tajikistan is a disaster prone area with frequently occurring earthquakes, mudflows, landslides and debris flows (The World Bank, 2008). The tectonic, topographical and climatic settings explain the high susceptibility to hazards in part. However, an increase of the impact of natural hazards has been observed in recent years. The high impact is attributable to the unpredictable intensity and frequency of natural events (Government of Tajikistan, 2008) and possibly connected to climate change, besides socio-economic factors (UNISDR, 2010; Swarup, 2009).

The former republic of the Soviet Union is the poorest country in Central Asia (Chabot and Tondel, 2011; Heltberg and Bonch-Osmolovskiy, 2011). The political and economic transition created or increased amongst others land tenure problems, shortages in goods and in energy supply in addition to high unemployment (Breu and Hurni, 2003; Hoeck et al., 2007; Shigaeva et al., 2013).

After the Soviet collapse in 1991 and the subsequent civil war from 1992 to 1997, local industries and the collective farming system of the Soviet economy broke down (Oxfam, 2011). As a consequence rural people were forced to resume work in subsistence agriculture (Breu and Hurni, 2003; Oxfam, 2011). Due to labour division during Soviet time, traditional farming practices were lost. The former collective land was mainly divided into *dekhan* farms (collective property shares) and household plots.

More than fifty percent of the Tajik population of 8 million (TAJSTAT, 2013) earns less than 1.33 US Dollars per day (FAO, 2008; FAO and Ministry of Agriculture, 2011), which is close to the international poverty line (Ravallion et al. 2008). Due to income insecurity in the country, one third of the economically active population works abroad. This labour migration male dominated and usually long-term. Remittances account for up to 50 % of the gross domestic product of Tajikistan. The women left behind subsequently take over the responsibility for the house, family and land (Heltberg and Bonch-Osmolovskiy, 2011; Ministry of Agriculture of Republic of Tajikistan et al., 2011; Swarup, 2009).

Muminabad

Scientific literature about Muminabad remains limited. Most information relied on in this study is based on internal Caritas reports and the District Development Plan (Local

Development Committee Muminabad LDC and Caritas Switzerland LDM, 2006), which will not be specifically cited in the following sections.

Extending over an area of 880.6 km^2, Muminabad district is located in the eastern part of the Khatlon Oblast in Tajikistan. The total number of inhabitants in the district is estimated at 76'000 people with an annual growth of approximately two percent. The district is characterized by a hilly area in the west and the mountainous Hazratishoh range in the east with peaks reaching 3200 m a.s.l. (Sosin, 2012).

Total precipitation in Muminabad is 800 mm per year with an irregular seasonal distribution. In summer and autumn 100 mm of average precipitation is recorded and 700 mm in the winter and spring months. The months July, August and September are dry (Figure 1).

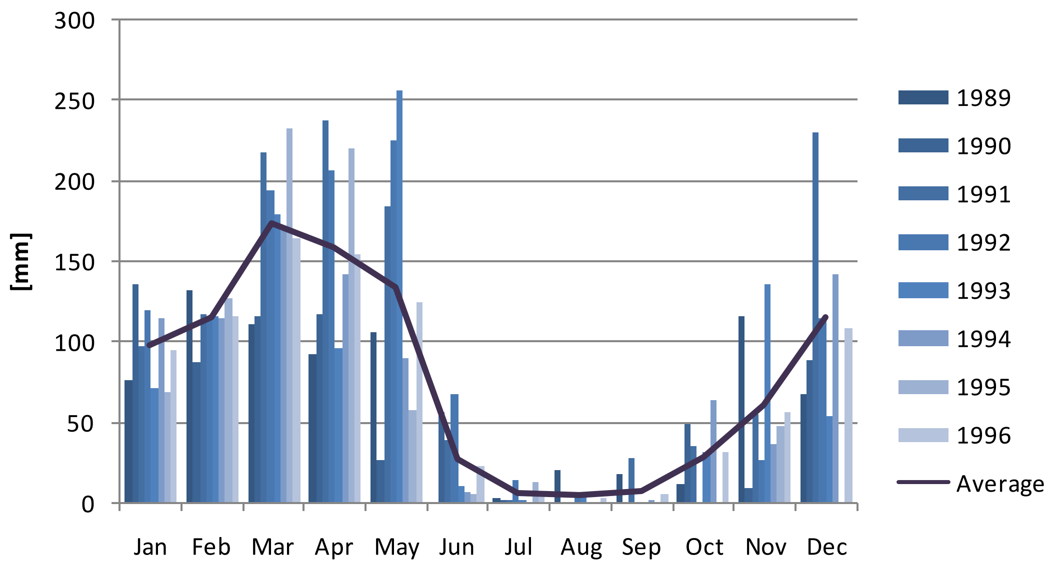

Figure 1: Average monthly precipitation rates [mm] for Muminabad between 1989 and 1996. Source: Weather station Muminabad (Sosin, 2011).

Rainfall rises with altitude, more precisely by 40 to 80 mm per 100 m of altitude in average. The annual rainfall amount is therefore expected to be twice as high in the upper zone of the watershed (lying at 2600 m a.s.l.) than in the district center Muminabad (lying at 1240 m a.s.l.) (Sosin, 2011, 2012). Despite predicted temperature increases for Central Asia no local predictions exist for Muminabad (Lioubimtseva et al., 2005).

The Hazratishoh range had been incised by multiple canyons through erosive processes during the early orogenic phase. The geological base of the range is of sandy-clayley origin. The Aeolian sediments, known as loess, overlaid the bedrock after the climatic aridification in the Quaternary. Loess covers reach thicknesses up to some tens of metres in the Hazratishoh range (Sosin, 2011; 2012). Loess soils are highly fertile and show good aeration and water storage properties (Catt, 2001).

Muminabad town lies partly on a debris cone, built by active and regular sediment transports coming from the upper zone of the watersheds (Sosin, 2011). Many settlements in the valley bottom are located in areas of disaster risk, due to the exposure towards fluvial events (Figure 2). In the past dams and channels were constructed to protect the population and settlement from damages. However, lacking maintenance and supervision of the structures the protection provided decreased. Inadvertently, the structural measures transmit a false feeling of security. It resulted in an expansion of the settlements on the fan towards the old dams, which increased the exposure to disasters (Lehmann, 2003).

Figure 2: Floods in the valley of Muminabad District occurred in the month of May (Picture: Q. Shokirov 2012)

Despite the hilly relief, the majority of the active population is working in agriculture (FAO & Ministry of Agriculture, 2011). Almost 80% of the land in Muminabad district is used for farming. The main crop type is grain, of which wheat is the most frequently sown cereal (Chabot and Tondel, 2011; Ministry of Agriculture of Republic of Tajikistan et al., 2011). Crop irrigation is largely rain-fed based. According to the District Development Plan only ten percent of the totally 12’000 ha of arable land is irrigated. The infrastructure for irrigation dates back to Soviet times and is in dire need of overall renovations and reconstruction (Kienzler et al., 2012).

Besides remittances, agriculture is the main source of income in Muminabad. Agriculture is based on subsistence or near-subsistence farming in Muminabad. On average, 70 % of the yield is designated for household-consumption whereas 17 % are used as fodder and 13 % are brought to market (Ministry of Agriculture of Republic of Tajikistan et al., 2011). Many subsistent households are very vulnerable to crop failure. Poor harvest endangers livelihoods by pushing numerous families deeper into poverty. Estimated 60 % of the population in Muminabad is living under the poverty line. Due to the widespread poverty natural resources are overexploited, which again raises the vulnerability and food insecurity of the rural communities in Muminabad. The rural population is increasing in Muminabad, this phenomenon can be observed across the country. Linked to a higher demand of natural resources, the pressure and degradation of natural resources are simultaneously increasing (chapter 3.1).

In total 69`000 ha are used agriculturally, whereas actually only 12'000 ha of arable land exist in the district. Unsuitable farming techniques and mono-cropping, mainly of wheat, lead to soil erosion and excessive runoff, besides a decrease in soil fertility and productivity. Manure, a natural fertilizer, is removed and use for heating and to cook food.

In addition, the inappropriate land use practices and the low quality of seed in addition to low agricultural inputs affect the productivity of crops. The lower harvest and income, results in a smaller purchasing power of the farmers for agricultural input supplies. Few agricultural investments are observed in the district as the poor farmers are constrained to profits gained immediately from the crops. In addition to the inability to invest an unwillingness to do so can be observed due to the uncertainty of property ownership and short-term lease of land generally.

Another major problem consists of the deforestation in the upper parts of the district for the energy supply of households. Wood became the most important source of energy after Soviet times. Moreover the houses are generally badly insulated, the ancient heating system is out of use and alternative energy sources are hardly available.

Muminabad has 50'000 ha of pastures, which are all overgrazed due to a rapidly increasing number of livestock. Between 2002 and 2006 livestock increased by a factor of six. Furthermore, the remittances, coming from family members working abroad, are preferentially invested in livestock, accelerating the downward spiral of land degradation (Eggenberger, 2011). Overgrazing is observed especially in pastures situated close to the settlements in the valley of the district. Trampling and grazing decrease plant diversity, reduce vegetation cover and cause soil compaction (Casenave and Valentin, 1992; Märker et al., 2008).

Inhabitants of the Muminabad district have recently observed an increase of disasters, like floods which in turn cause sediment transport. Local meteorological data, although of poor validity, do not show a significant change in climate in the areas. This underlines that disaster frequency increased with increased runoff, caused upslope from the watershed.

2.2 Institutional framework

Swiss Agency for Development and Cooperation

The Swiss Agency for Development and Cooperation (SDC) is one of the agencies working in Tajikistan on long-term development cooperation (Swiss Cooperation, 2013). In addition to economic and educational programmes in Tajikistan, SDC focuses its international cooperation on disaster prevention, mitigation and response. These activities are part of the strategic objectives and the humanitarian aid strategy for 2013 to 2016. The aim is to address the social consequences of environmental and human impacts.

The SDC guidelines on DRR, approved in 2007, established an implementation plan for Tajikistan. The guidelines consist of three strategies: DRR is integrated in the processes and instruments of SDC in all project countries at high or considerable risk; SDC supports DRR related activities of targeted partner communities; and SDC supports international institutions working in DRR at local and international level (Lehmann et al. 2008).

Caritas

Caritas Switzerland is actively working in Muminabad with the support of SDC. Caritas Switzerland started to work in Tajikistan in 1995. Five years later Muminabad was included in the Caritas Switzerland programme of Local Development Muminabad (LDM).

The programme of DRR by Caritas Switzerland encompasses adaptation and preparedness, prevention as well as climate change mitigation. The aim is to reduce vulnerability and potential impact, while simultaneously rising resilience and preparedness of the affected communities. Strengthening the knowledge and capacity is primary to adapt to changing climatic conditions.

The first project in the framework of DRR in Muminabad was the River Bank Protection Project within the Disaster Risk Management Programme in 2004. The project was successfully completed through constructions along selected river sections and soft measures. The aim was to improve the awareness, knowledge and mobilization of the local society and government for rising projects against disasters. The Watershed Management Pilot Project initiated in 2010 also addressed DRR. It focuses on its source by reducing the degradation of natural resources and soil erosion (Lehmann, 2003). The Watershed Management Project (2009 - 2011) realized by Caritas Switzerland and Caritas Luxembourg gave rise to pasture management projects, reforestation projects and community mobilization through livestock committees. Since 2011 Caritas Switzerland focuses on two development programmes, namely Income Generation, and Integrated Watershed Management, which is funded by SDC and forms the institutional framework of this study.

2.3 Integrated Watershed Management by SDC

Environmental issues within a watershed cannot be approached separately because different stakeholders, upstream-downstream dynamics and multidimensional interactions are involved. Meaningful solutions and a sustainable development of a natural composite demand an institutional integration of socioeconomic, political and environmental aspects (Ferreyra et al., 2008). Since the 1990s watershed management takes an inherent place in participatory, and decentralized development programmes to reduce rural poverty (Darghouth et al., 2008). Integrated watershed management protects livelihood of the local society by promoting a sustainable planning of resources, preventing soil depletion and mitigating the adverse effects of disaster. With the aim of “Sustainable Mountain Development”, the integrated watershed management figures in the Agenda 21, approved at the UN Conference on Environment and Development in 1992 (FAO, 2006).

The aim of the Integrated Watershed Management (IWSM) in Muminabad is to:

> ”reduce natural disaster risk of the population in the project area and minimized impediments to sustainable livelihood development by introducing and further consolidating natural resources management approaches in line with IWSM principles“

The 3.5 year programme is a co-project of the “SDC DRR-IWSM Initiative” implemented from 2011-2014 by Caritas Switzerland with the financial support of the SDC. The initiative aims to empower the citizens through improved knowledge and participation in decision-making processes in cooperation with the local government. Simultaneously, participation of the government in disaster resilience and prevention is expected. The initiative comprises of two phases. The first phase consist of building up the institutional framework and definition of target groups and the second phase focuses on fostering local capacity with the aim to improve land use planning and livelihood, and reduce disaster risk within a sustainable and integrated watershed management.

3 STATE OF THE ART

3.1 Land degradation

Land use is human activity directly related to land, making use of its resources or having an impact upon it (Liniger, Schwilch, et al., 2008). Inappropriate land use enhances soil erosion, and water and biological degradation (Eswaran et al., 2001; Liniger et al., 2008; UNEP, 2006).

There is a wide range of definitions and terms concerning land degradation. Eswaran et al. (2001) define land degradation as "the loss of actual or potential productivity or utility as a result of natural or anthropogenic factors; it is the decline in land quality or reduction in its productivity."

Degradation of land is a matter of concern at global level. Dry areas are estimated to be degraded by 70 % (Eswaran et al., 2001). The definition of land degradation does not refer to a specific soil type, land use or climatic zone. However degraded land may originate from different circumstances and have different impacts on the local environment (Hurni et al., 2007). Due to the severe stage of global degradation, the United Nations Conference on Environment and Development incorporated activities to combat and reduce land degradation and desertification (United Nations, 1987).

Socioeconomic and political drivers determine the biophysical process of land degradation. The growing human population increases the pressure on soil due to a higher demand of land and its functions. This includes deforestation and land-use conversion for agricultural purposes (Lal, 1997; UNEP, 2006). Land degradation affects the primary production of goods (Corvalan et al., 2005). In contrast to economically developed countries, poorer countries rely predominantly on agricultural production (FAO et al., 2011). To ensure livelihood of rural people in developing countries, natural resources must be equitably accessible and well conserved (Swarup, 2009; UNEP, 2006; WFO, 2012; IAASTD 2013).

In Tajikistan agriculture is the main source of income. Rising population and poverty rates, improper use of natural resources and land tenure problems contribute to land degradation. The rural population doubled from 1979 to 2009, while the area of arable land stayed constant in the same period (UNEP, 2006).

Pressure and mismanagement lead to land degradation and decreasing yields. Kienzler et al. (2012) states that in the last two decades crop yields became less predictable in Central Asia. The lack of traditional farming systems, assistance and advisory trainings in addition to rising prices for agricultural inputs, provoke further food insecurity and environmental degradation (Kienzler et al., 2012).

Deteriorated soil loses its capacity to provide economic goods and services and environmental regulations (Lal, 1997). It is widely known that fertility decline of degraded land coincides with the decreasing ability to cohere particles, to infiltrate and to store water (Casenave and Valentin, 1992; Cerdan et al., 2001; Märker et al., 2008). Degraded soil is more vulnerable and sensitive to heavy weather events and land use changes with a greater susceptibility for water and soil erosion (Ayed and Mohammad, 2010). At the same time, it is commonly agreed that depleted soil bears lower adapting capacity to climate change (Séguis et al., 2004; Swarup, 2009; UNEP, 2006). Especially loess under cultivation is susceptible to soil crusting, soil erosion and runoff, reduced yield and loss of organic matter. Worldwide studies in loess areas underline this finding (Casenave and Valentin, 1992; Catt, 2001; Huang et al., 2003).

These impacts are of particular concern since hills in Muminabad are loess dominated, and are affected by land degradation. Therefore the population of Muminabad is particularly affected by land degradation, by the adverse socio-economic and political drivers and biophysical (pre)conditions.

In order to assess the state of soil of an agricultural plot, productivity serves as an immediate indicator. For long-term predictions soil organic carbon (SOC) is used in many research studies (Kienzler et al., 2012). SOC is an indicator for soil quality and strongly related to land use. Especially in the loess hills, land use regulates the organic carbon content. SOC depends on management practices, soil type and climatic condition and influences the productive capacity directly on the fields (Pulido-Fernández et al., 2013; Wolfgramm, 2007; Lal, 1997).

SOC depends on soil texture, climate, vegetation and land use in the past and present (Milne, 2012). As soil texture and climate are not expected to vary greatly in Muminabad, vegetation cover and land use practices are the decisive factors for the SOC content and runoff behaviour.

3.2 Runoff

Runoff depends on physiographical and environmental properties of the watershed. Besides rainfall and storm characteristics, slope steepness, the area extent, and altitudinal gradient of the watershed partly explain runoff behaviour (Casenave and Valentin, 1992; Euler and Knauf, 1999). In addition, it is commonly known that land use has a crucial influence on runoff generation (Kosmas et al., 1997; Cerdan et al., 2001; Huang et al., 2003).

There are many properties and processes in soils, which influence runoff and infiltration respectively. As processes may reinforce each other, a determination of all runoff relevant factors is complex. In this study, focus is placed on the visual indicators of soil crusting, vegetation cover and soil roughness to identify the susceptibility to runoff and the infiltration capacity of soils respectively.

Infiltration capacity depends largely on the characteristics and type of soil. Soil crusting has a great effect on runoff and soil erosion, by influencing the infiltration rates and the detachment and transport of sediments. Vegetation cover acts beneficially on infiltration in many ways: It reduces the erosive forces and the volume of rain which reaches the soil.

Moreover, preferential flow paths along roots facilitate water infiltration. Finally, infiltration capacity increases with soil roughness (Casenave and Valentin, 1992; Cerdan et al., 2001).

The loamy soil of the loess hills in Muminabad are very prone to surface crusting and water erosion, because of a low content of clay and organic matter (Cerdan et al., 2001). This is insofar of particular relevance as the loess soil in Muminabad is not capable of sorption of heavy rainfall. Combined with the on-going land degradation, runoff and disaster may be increased (Catt, 2001).

Many eroded areas, gullies and rills can be observed in the slopes of the watersheds in Muminabad, indicating the high frequency of hydrologic and soil processes (Figure 3).

Figure 3: Heavily eroded pasture in Muminabad District.

Excessive runoff generates due to low infiltration capacity of poor soils (Séguis et al., 2004). As stated above, human activities enhance water and soil erosion. Cropping on steep slopes, leads to a reduction of vegetation cover while soil erosion and runoff increases. Inappropriate land use practices, as vertical ploughing with heavy machines, compact the subsoil, induce soil crusting and change the surface roughness. Mono-cropping impoverishes the water and nutrient availability of soils and reduces the cohesion of particles. Deforestation and overgrazing alter the vegetation cover and diversity, and simultaneously destabilizes and compacts soil.

An increase in runoff and disasters is already observed by the community of Muminabad, although precipitation predictions do not show a clear trend for 2020-2080 in Central Asia (Lioubimtseva et al., 2005). Runoff simulations by Vlieghe (2012) for the Obishur and Chukurak watersheds of Muminabad show a potential for runoff reduction of up to 20% and 17% respectively through improvements of land use practice. Without an integrative approach and sustainable solutions on watershed scale, land degradation and disasters frequency is expected to increase (Darghouth et al., 2008; Lehmann et al., 2008).

3.3 Disaster risk reduction

Disasters, whether natural or human induced, are hazards that are likely to cause damage on people, property and environment. Risk is the probability and the degree of possible damage caused by a hazard. Thus, risk can be expressed as a product of hazard and vulnerability. Hazards are threatening events or in other words, the probability of occurrence of a potentially damaging phenomenon within a given time period. Vulnerability is the degree of loss (Equation 1)(EM-DAT, 2013):

$$\boxed{\text{Risk} = \text{hazard} \times \text{vulnerability}} \qquad \textbf{Equation 1}$$

The impact of damage depends on the capacity of the affected person or goods to cope with the natural events. This capacity results from the degree of exposure to experience hazards and from the vulnerability. The latter is conditioned by physical and socio-economic factors, which influence the susceptibility of a person or object to the impact. Even if hazards cannot be completely avoided, risk can be diminished when hazard, vulnerability or both are reduced. The concept of DRR identifies and manages the causes of disasters and aims to reduce hazards and vulnerabilities. Simultaneously DRR strengthens programmes to improve land use practice and social preparedness (UNISDR, 2007).

DRR is of great concern as an increased number of disasters and of affected people is recorded globally (UNISDR, 2007; Lehmann et al., 2008). It results from a growing population and vulnerability towards hazards, overuse of natural resources, a lack of political support and awareness-building institutions (Lehmann et al., 2008). To reduce the extent and impact of disaster the legally non-binding Hyogo Framework for Action (HFA) was adopted by 168 governments at the World Conference on Disaster Reduction in 2005 (UNISDR, 2007).

The HFA serves as an approach to implement the objectives of DRR into activities of different administrative levels. The main aim is “the substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries” (UNISDR, 2007). An efficient implementation of DRR presupposes several basic conditions. It is in the primary responsibility of the state to promote DRR, by integrating risk and protective activities into its development plans. Therefore, it is crucial to improve the capacity of the societies and institutions from local to national level to overcome risks. Participation of communities strengthens knowledge and preparedness against natural hazards. A multi-hazard approach and hence a differentiated strategy is required, as a disaster may origin from diverse natural and anthropogenic forces affecting people with an unequal social and economic status (UNISDR, 2007).

Furthermore, DRR postulates the importance of prevention and mitigation, turning away from pure response activities. The principal goals of DRR consist of a reduction of existing risk by decreasing hazards and vulnerabilities, a continuous adaptation of emerging risk factors and a prevention of arising vulnerabilities in future. As preventive measures are mostly non-structural and hence invisible, they face a lack of acknowledgement. Therefore a multi-stakeholder participation and incorporation in decisions and activities should be promoted in order to increase the awareness and knowledge of the concerned community (Lehmann et al. 2008; UNISDR 2007).

The HFA acknowledges the importance of risk reduction in agriculture, as it is a key sector to ensure people's livelihood. A specific use of natural resources and human activities turns every production of goods and services vulnerable to particular natural hazards (UNISDR, 2007).

This is of particular concern in Tajikistan as the country is regularly hit by weather extreme events and most of the people´s livelihood depends on agriculture. Tajikistan records some 3000 disasters per year, mainly mudflows, landslides and floods, which occur mostly in spring and early summer (Government of Tajikistan, 2008). An increase of sediment transport, runoff, floods and disasters coming from the upper zones of the watersheds is also observed in Muminabad, in the rainy spring season (Wolfgramm et al., 2012). The villages located at the debris cones of the valley in the district are particularly vulnerable to these hazardous events and are regularly confronted by damages. As disaster recovery burdens the district budget, financial support lacks for prevention and mitigation programmes.

The occurrence of disasters and degradation of natural resources roots in complex cause and effect processes on political, economic and educational level. Therefore, it is crucial to approach DRR through integrated measures to treat primarily the causes rather than the symptoms of natural hazards (Darghouth et al., 2008; Ferreyra et al., 2008). The current DRR-IWSM-Initiative by SDC and Caritas Switzerland aims to reduce the occurrence and impact of disasters trough an integrative and participative approach on a long-term basis in Muminabad (FAO, 2006; P. Lehmann et al., 2008).

4 CONCEPTUAL APPROACH

4.1 Driver-Pressure-Impact-State- Response

The Driver – Pressure –State – Impact – Response (DPSIR) framework represents a causal chain between local settings and environmental problems (Figure 4). The multi-level framework puts changes of the environment, their impacts and potential fields of intervention into relation. Driving forces, as primary drivers, are understood as the socio-political, economic and ecologic background, out of which pressures are originating. Pressures have a direct influence on the condition of the environment, defined as state. Pressures affect and modify the quantity or quality of state, causing impacts (Smeets and Weterings, 1999). The impact might be advantageous or disadvantageous, directly or indirectly, on short- or long-term, concerning the social, ecologic and economic dimension. The response can have direct repercussions on the drivers, pressures, state or impacts. Without a response the drivers and pressures will foster negative impacts and deepen the vicious circle. To avoid or reduce negative impact on long-term, sustainable interventions must be undergone (Liniger et al., 2008b).

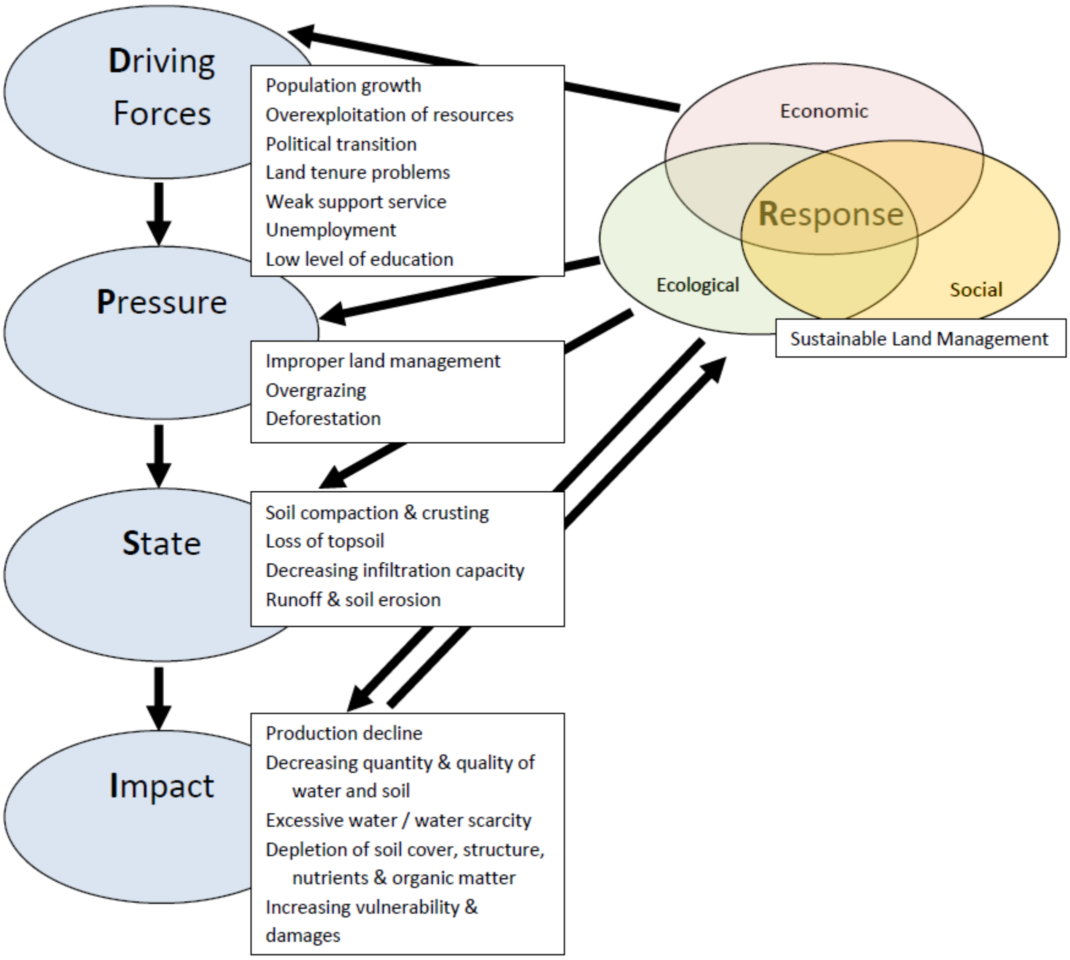

Figure 4: DPSIR-Framework in the context of Muminabad. Adapted after Smeets and Weterings (1999) and (Liniger et al., 2008b).

Drivers like the adverse situation of population growth, over-exploitation of natural resources, poverty, land tenure problems, lack of income alternatives and labour migration, weak institutional and financial support, and low quality of education are sources of pressures.

Improper management of soils and croplands, overgrazing and deforestation are the main pressures which alter the state of the natural capital.

The watersheds of Obishur and Chukurak are mainly affected by soil erosion through water, physical soil deterioration and biological degradation. The compaction, crusting and low infiltration capacity of the soil generates off-site effects such as excessive runoff and downstream flooding. Overgrazing and inappropriate land use causes changes of the state by declining vegetation cover and biodiversity.

The change of state implicates different types of impact on productive services, ecological services and socio-cultural services defined by the Millennium Ecosystem Assessment (Liniger et al., 2008a).

In Muminabad, a production decline of goods, animals and energy is observed in addition to water and land scarcity. The regulatory and supporting function of water is disturbed, which is important in case of extreme weather events and in regard to the predicted increase of temperatures. The generally sparse vegetation cover, low organic matter and nutrient content of soils, and the weak soil structure indicate the deteriorating state of the supporting function of soils. Land degradation and excessive runoff have negative impacts on the agricultural productivity and increases the risk of floods and mud flows. The affected local community is pushed into further poverty, food insecurity and vulnerability to disasters. To reduce and eliminate the impact of resource overuse, WOCAT (World Overview of Conservation Approaches and Technologies) proposes SLM as a response.

4.2 Sustainable Land Management

WOCAT uses the following definition of SLM:

> „the use of land resources, including soils, water animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions."(Liniger et al., 2008a)

SLM is based on the concept of sustainability. According to the World Commission on Environment and Development "Sustainability meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987). Sustainable development is only possible if the social, economic and ecological dimensions are preserved for the long-term.

The drivers and pressures in Muminabad are of multidimensional concern, which demand for sustainable responses. Furthermore a differentiated stakeholder approach has to be considered in this study, to guarantee a successful implementation of SLM. Farmers, the local government and institutions should all be involved and responsible for a sustainable development in Muminabad.

As seen in the previous subchapter, land use practices influence the state of soil. Improper land use may provoke excessive runoff and land degradation, leading further to productivity decline. Therefore, the management of land is crucial when talking about runoff reduction and soil quality. To ensure livelihood on long-term sustainable land management plays a key role.

4.3 Research approach

Details about the methodological process within the research approach are described in Chapter Five.

A research approach was designed and divided into intermediate steps to reach the main objectives of the study (Figure 5). First, study plots are selected according to different criteria described in chapter 5.2.2, second the plots are subjected to CBA (chapter 5.4). Benefits are further compared by using spider webs. Benefits will be approached quantitatively, through measurements and modeling. Qualitative methods consisted of interviews and a visual field assessment. The different approaches allow a triangulation of methods. In a final step, scenarios are elaborated to quantify the potential runoff reduction by improved management in the watershed.

Within a watershed, the focus was placed on the middle zone, where the study plots were selected.

The middle zone is defined, following Vlieghe (2012). For the Obishur watershed the middle zone comprises the area between the water channel on the fans and 2000 m a.s.l. and for the Chukurak watershed between the upper limit of the fans and 2000 m a.s.l.. The middle zone was adjudged as an effective area of intervention by the locals at the SLM decision support workshop, held in Muminabad the 2-4 May 2012 (chapter 5.3.2). Furthermore, the hydrologic analysis by Vlieghe (2012) showed that runoff contributions from the middle zone are very important in both watersheds. Around 45 % - 70 % of the total runoff is generated in the middle zone of the Obishur and Chukurak watershed respectively. For these reasons the focus of this study is placed on the middle zone.

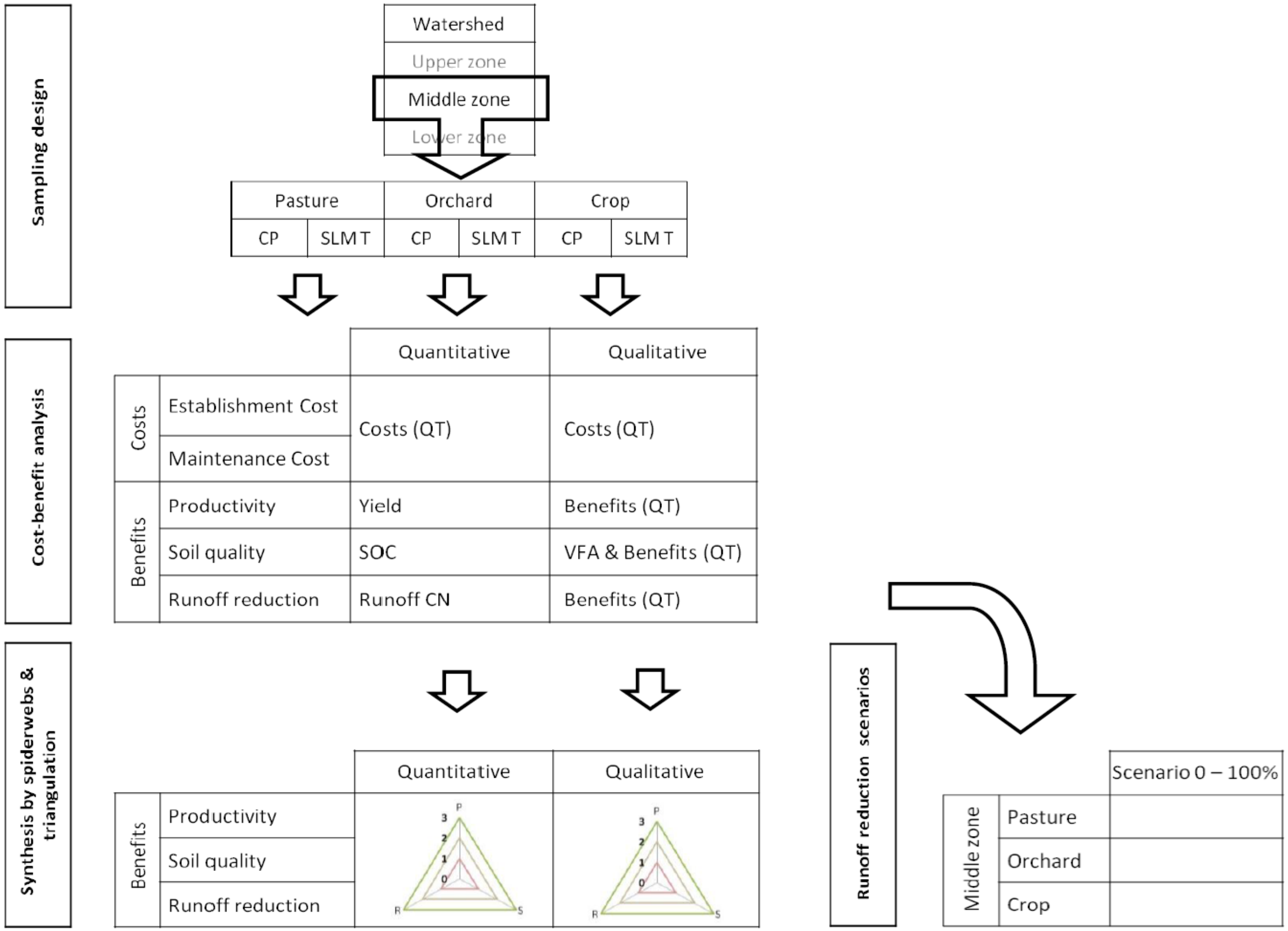

Figure 5: Research approach consisting of the study plot selection (sampling design), the cost-benefit analysis and the synthesis and triangulation by means of spiderwebs With a further step of runoff reduction scenarios. With CP= Common practice and SLM T= SLM Technology.

5 METHODS

5.1 Study area

The SDC DRR-IWSM Initiative implemented by SDC and Caritas Switzerland focuses geographically on the Obishur and Chukurak watersheds. Both are part of the Hazratishoh-range in Muminabad District (Figure 6).

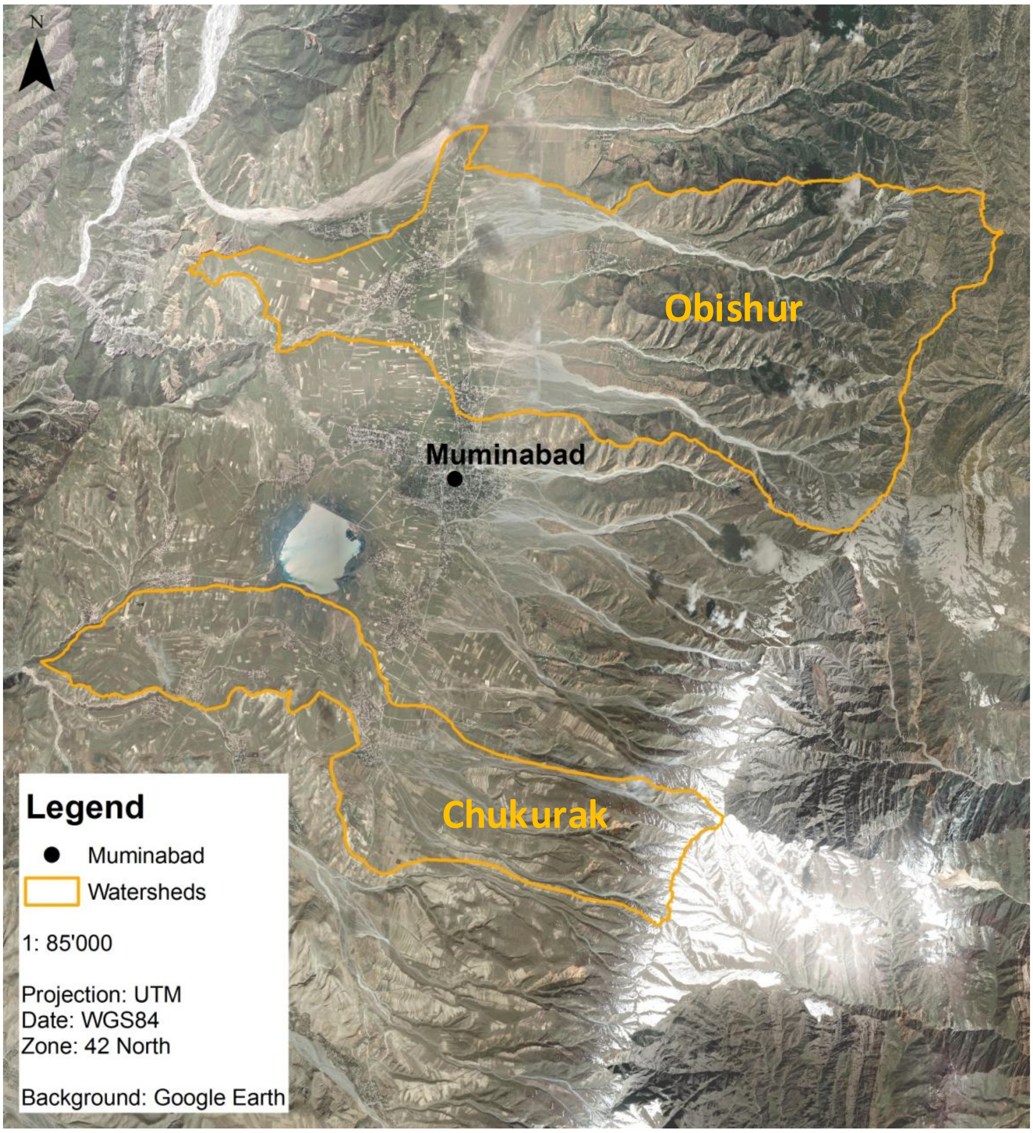

Figure 6: Muminabad and the watersheds of Obishur and Chukurak (Google Earth 2003 and 2006)

The watersheds have similar physiographical properties, but they are distinct in the division of sub-watersheds and slopes and the extent of area. Land use of both watersheds is the same, although the proportion of the three main land use types differs (Table 1).

Table 1: Characteristics of the watersheds within the framework of IWSM by Caritas Switzerland. Area data in ha.

Watershed	Obishur	Chukurak
Population	8965	5978
Total area	7719 ha	3608
Pastures	3040 ha	2350 ha
Orchards	400 ha	290 ha
Croplands	1790 ha	1602 ha
Livestock units	8000	4400

Obishur accounts for twice the size and double the livestock number of Chukurak. However the area of pastureland is comparable between the two watersheds. These numbers indicate that livestock pressure is much higher in the Obishur. Chukurak has a high area of cropland compared with Obishur. In both watersheds orchards only have a small area extent.

The Obishur and Chukurak watersheds consist of several sub-watersheds. Their morphology and size may influence the natural hydrograph and hence runoff patterns (chapter 3.2). The elongated form of the watersheds and the moderately branched water courses in the watersheds indicate less pronounced runoff peaks in the hydrograph.

The study focuses on the middle zone of the watersheds. The middle zone of Obishur extends from the canal and to the contour line of 2000 m. A canal and dike are installed in Obishur, which modifies the natural hydrograph. Runoff of all sub-watersheds is redirected to a culvert, which regulates exceeding runoff. In Chukurak the middle zone extends from the foot of the fans to the contour line of 2000 m. A dike protects the underlying settlement on the fan.

The consideration of both watersheds for the study allows comparing, finding similarities and differences of the on-and off-site benefits. Precondition is that physical properties and rainfall characteristics are similar (Huang et al., 2003). Although poor to no data exists, Obishur and Chukurak watersheds are considered to have similar patterns due to their geographical vicinity. Both watersheds have a comparable altitudinal gradient, exposition, a geologic and geomorphologic origin, and are heavily modified by human activities.

5.2 Sampling design

To assess on- and off-site benefits of SLM technologies a paired case study approach was chosen. The idea is to compare plots of CPs, with the SLM technologies by comparing cost and benefits. The paired approach allows to compare the effectiveness of improved land use by SLM technologies, as a long-term study was not possible to conduct (Huang et al., 2003).

To understand the methodology of the study plot selection, following terminological definitions have to be considered:

- Land use type represents the way land is used agriculturally. For this study the focus is placed on pastures, orchards and croplands.
- Land use practices distinguish between CPs and SLM technologies:
    - CPs are widespread practices, which do not respect the sustainable use of natural and human resources, leading to land degradation and productivity decline.
    - SLM technologies are innovative and resource-conserving practices, ensuring the preservation of the environmental services on a long-term basis.

The land use type defines what, and the land use practice classifies how land is used.

5.2.1 Land use type

For the CBA of the plots three land use types were selected. Pastures, croplands and orchards are the three main land use types in the study area (personal consultation Caritas). Pasture is the most important land use type by size. Signs of overgrazing, soil erosion and land degradation indicate the poor state of the pastures. Especially pastures near settlements are overgrazed due to easy accessibility and availability of water points (Vanselow et al., 2012). One third of the total area of the Obishur and Chukurak watershed is used as cropland (Table 1). Orchards date back from Soviet times. They were mostly abandoned after the Soviet break-up, few were maintained or reestablished (Eggenberger, 2011).

5.2.2 Land use practice

Overexploitation of natural resources through inappropriate land use is at the origin of land degradation and excessive runoff in Muminabad. Depending on the land use practice, a different impact and a different degree of impact on natural resource can be observed.

Differences in land use practices per land use type were first discussed with Caritas Switzerland, and were followed by own field observation. The objective was to find examples of CPs and SLM technologies of each land use type within a watershed in order to compare cost and benefits.

When conducting a comparative case study analysis, it is assumed that basic physical and geographical characteristics have to be similar between the studied plots. In order to detect differences that can be attributed to land use practices, external factors are kept similar

(Huang et al., 2003). Based on this assumption, exposition, slope, and altitude were chosen as similar as possible for plots within a land use type and in the two watersheds.

Indicators

Land use practices influence the state of land resources on the agricultural plots. For the study, three CPs and SLM technologies of each land use type were selected per watershed. An evaluation of the state of soil and vegetation on each plot allowed selecting and classifying the study plots into CPs and SLM technologies. The evaluation is based on the DPSIR framework (chapter 4.1) of which the following degradation indicators were used for the classification of land use practices:

- Pastures: vegetation cover, soil erosion (rills or gullies), homogeneously or heterogeneously grazed
- Orchards: vegetation cover, soil erosion (rills, gullies), fence or guarding, tree maintenance
- Croplands: vegetation cover, soil erosion (rills or gullies), fence or guarding, contour or vertical ploughing, slope

Some indicators are used for all the plots (vegetation cover, soil erosion) others are used for one specific land use type and its management.

Common Practices

CPs concern land use which leads to land degradation and consequently have negative impacts on social, economic or ecologic assets (Lal, 1997). CPs are widespread in the study area, being source and result of and generating land degradation (chapter 1.1). Therefore, examples are easy to find in the study area.

SLM technologies

SLM technologies are land conservation measures proposed by WOCAT with benefits on social, economic and environmental aspects. Good management practices and innovative farming systems are rare in Muminabad District, which makes the selection challenging. Especially pastures are poorly managed, of low quality and high degradation is common.

5.3 WOCAT

The network of WOCAT was initiated in 1992 to combat soil erosion and the fertility decline. It aims is to globally combat soil erosion and the fertility decline by acting on local level. The goal of the Soil and Water Conservation (SWC) scientists was to spread knowledge of good practices. SLM allows the protection of soil, water and vegetation resources while improving soil fertility simultaneously. As know-how of SLM practices is insufficiently documented and disseminated, WOCAT‘s mission is to promote innovation, exchange experiences and enhance capacity. The standardized documentation of global soil conserving SLM practices supports analysis, monitoring, evaluation and decision-making in order to upscale good practices among different stakeholders. A wide range of SLM technologies is worldwide successfully applied, presenting good examples of resource management to be spread (Liniger et al., 2008a; WOCAT, 2013).

5.3.1 Technologies Questionnaire

To analyze and evaluate SLM, WOCAT developed different questionnaires, including the questionnaire on SLM technologies (QT). The purpose of the QT is to specify the applied technology, to place it in its natural and human context and to assess its impact. SLM technologies are land conservation measures of agronomic, vegetative, structural or management origin. A combination of measures is possible as they are complementary (Liniger et al., 2008a). Examples for each conservation measures are:

- Agronomic: rotational cropping, no tillage, mulching
- Vegetative: grass strips, tree planting, agro-forestry
- Structural: terraces, waterways, diversion or infiltration ditches
- Management: change of land use type or practice, fencing, environmental adaptation

The QT has three main sections consisting of general information, specification and analysis of the SLM technology. All chapters are used for the documentation of the selected study plots. For CPs, the subchapters of QT about characterization, purpose and benefits of the technology[1] are not taken into account as no technology in a strict sense is applied. Special attention is paid to the technical specifications, implementation activities, inputs and costs, the benefits and disadvantages and the economic analysis[2].

5.3.2 Materials from the SLM Decision Support Workshop May 2012

In May 2012, a SLM Decision Workshop was held in Muminabad. It was organized as part of SDC's IWSM initiative by the Centre for Development and Environment (CDE) and in collaboration with Caritas Switzerland the support of SDC and involved different watershed stakeholders. The workshop was adapted from the workshop guideline for plot level decisions support available from the DESIRE (Desertification mitigation and remediation of land) project and CDE (Schwilch et al., 2013).

The goal of the workshop was an evaluation and selection of SLM technologies following three steps. First, disturbances in the watershed were identified for the zones of the watersheds. In a further step, potential solutions were selected and identified from the WOCAT database. Finally, the proposed SLM technologies (from Tajikistan, Central Asia and worldwide) were scored and the best options selected.

[1] chapters 2.2.2, 3.1, 3.2 and 3.3 in the WOCAT QT
[2] chapters 2.5, 3.1 and 3.2 respectively in the WOCAT QT

The output showed that the stakeholders were particularly concerned about the degradation of natural resources, irregular meteorological events and disasters. The participants listed decreased infiltration capacity and soil moisture as major problems of land degradation in the middle zone.

Water retention incapacity is caused by an inappropriate use of land and diminishing soil cover. In order to achieve sustainable land management, goals were formulated and possible technologies ranked and selected (Table 2).

Table 2: Goals, Technologies, Approaches and actors to combat land degradation in the middle zone of the watersheds in Muminabad. Selection made with the participation of different stakeholders during the SLM Decision Support Workshop in May 2012 (Wolfgramm et al., 2012)

Goals	Technologies	Approaches	Actors
- Improve soil quality and soil moisture **- Increase water retention in soils and decrease soil erosion**	1) Buffer zones between plots 2) Contour terraces 3) Pastures on community level 4) Tree and shrub plantation in erosion-prone areas	1) Learning from practices 2) Access to seeds and shrubs 3) Labour (men power) 4) Planting of perennial grass instead of soil tillage 5) Tree planting (poplar, willow)	1) Engineers 2) Community members 3) Farmer associations

Selected technologies consisted of the installation of buffer zones and tree and shrub plantation as vegetative measures. The building of terraces on contour lines as structural measure and pasture management on village level referred as management practice according the classification by WOCAT QT.

The SLM Decision Workshop serves as a starting position for the analysis of cost and benefits of different land use practices in Muminabad. The participants of the workshop being aware of the on-going land degradation formulated goals, which all concern soil quality. Different SLM technologies and approaches were proposed to raise soil quality in the watersheds. This study is based on the impact analysis of SLM technologies and gives information about the effectiveness of selected land conservation measures proposed during the SLM Decision Workshop (e.g. pastures on community level, perennial grasses, learning from practices). A part from the technologies and approaches proposed during the workshop, the current assessment reveals additional technologies with a potential to raise soil quality (e.g. combined agro-systems, fencing, contour ploughing).

The formulated SLM technologies at the workshop reflect the awareness of local people of soil depletion. Furthermore the technologies bear a certain acceptance among the local community, which is a precondition for their implementation.

5.4 Cost-Benefit Analysis

The CBA is an approach to evaluate the effectiveness, efficiency and impact of an activity. CBA assesses whether the activity or measure led to the expected effect, with benefits being more important than costs. Therefore the CBA is an instrument which enables the evaluation of the profitability of selected conserving measures. In this study the CBA aims to compare the monetary input and outcomes regarding the CPs and SLM technologies. The goal is to assess whether, and to what extent, the establishment of SLM technologies are beneficial and profitable (Ludi, 2002).

Profitability is a precondition for a technology to be of interest to farmers. However, the economic aspect may not be the decisive factor for the implementation of soil conserving measures. Strength of the cost-benefit analysis is the consideration of ecological and social benefits additionally to economic factors. Additionally, conserving measures may proof economic viability only many years after implementation and this may be deterring to farmers and present challenges to the CBA. Costs may be highest during the establishment phase, whereas benefits may arise later (Ludi, 2002; Riegg Cellini and Kee, 2010).

Thus, to consider the discounting rate in this study, the effectiveness of the CBA will be analyzed on a long-term basis: ten years after the establishment of a land use practice. Costs and benefits are assessed quantitatively and qualitatively. For the quantification of costs, runoff reduction, soil quality and productivity different methods are used (chapter 5.4.2 et seq.). The qualitative assessment of benefits is based on the WOCAT QT (chapter 5.3.1).

5.4.1 Costs

The calculation of the monetary input is very complex, as the costs cannot always be directly and readily identified. External costs and open access resources are not fully understood and known, and hence generally not taken into account (Riegg Cellini and Kee, 2010). The QT bases the cost analysis of technologies on a compilation of cost for establishment and recurrent activities and inputs. It includes activities (Equation 2: "Labour") and all agricultural and construction related material (Equation 2: "Input").

$$\boxed{\text{Cost} = \text{Labour} + \text{Input}} \qquad \textbf{Equation 2}$$

The compilation and overview of the costs for each conservation measure or CP is discussed in the questionnaire[3]. Costs are split in establishment costs and maintenance costs and calculated according to current prices per hectare.

[3] chapter 2.5 and 2.6 respectively in the WOCAT QT

The aim is to compare costs with yield to determine the net profit, in a short-term and in a long-term. In the analysis, short-term costs are represented by the establishment costs and long-term costs include establishment cost and maintenance cost over ten years.

5.4.2 On- and off-site benefits

Benefits are positive impacts attributed to social, economic and ecologic aspects (Riegg Cellini and Kee, 2010).

On- site effects have a direct impact on the field. Positive on-site impacts include an improved nutrient and water holding capacity of soils, increased soil depth and content of organic matter which leads to higher productivity (Ledermann et al., 2010; Mullan, 2013). Therefore yield and SOC were chosen as indicators for on-site benefits.

All impacts which occur outside or downstream of the field, are off-site effects. They are of economic or ecologic nature, as flood damages, sedimentation or eutrophication with effects on the social capital (Ledermann et al., 2010).

Runoff is a natural process and a substantial part on the water cycle. In contrast, excessive runoff may be source of disasters. Muddy floods are fluvial processes resulting from superficial water, containing suspended soil and originating from agricultural land (Ledermann et al., 2010; Mullan, 2013). Thus runoff reduction is considered to be the main off-site benefit in this study.

For this study, the overall benefit was defined in Equation 3 with three specific benefits. The benefits can be characterized either as on- or off-site benefits.

$$\boxed{\text{Benefit} = \text{productivity (on)} + \text{soil quality (on)} + \text{runoff reduction (off)}}$$

Equation 3 with (off)= off-site and (on)=on-site impacts.

For each specific benefit an indicator was determined. The selection of indicators was challenging due to limited time and resources during field research and the ambition to cover different on-and off-site impacts. The aim was to identify SMART indicators, which represent specific, measurable, attainable, realistic and time bound indicators (Doran, 1981). Yield is not the most reliable indicator for soil productivity but given local methodological limitations yield was an adequate indicator for productivity. The assessment by a yield questionnaire is a suitable approach on field, especially when contact with the farmer and information about the plot exists. Within the frame of the soil campaign held in autumn 2012 in Muminabad soil samples were taken to assess soil quality. The sampling needs qualified staff and good equipment which would burst the capacities and time schedules of a MSc study. As runoff from plots, as an indicator for runoff reduction was not measurable in the study site. But modeling of runoff corresponded with the objectives of SMART.

As no runoff data were available for the study area, runoff is estimated by means of the runoff curve numbers by the Technical Release 55 of US Department of Agriculture Soil Conservation Service (USDA SCS, 1986). Yield or the productivity of the field accounts as the direct benefit for the smallholding farmers. Yield for croplands and orchards for CPs and SLM technologies are assessed with a yield questionnaire. SOC indicates the health condition of the soil, influencing runoff behaviour and productivity.

Ecological and social benefit is difficult to monetize, hence a direct comparison between the quantified costs and the qualitatively assessed benefits is not possible.

Besides the quantification of runoff reduction, productivity and soil quality, the WOCAT QT can be used to assess benefits in a semi-quantitative manner. The dual assessment allows in a following step a comparison between the outcomes. Additionally, a visual field assessment of soil quality for each study plot was carried out. The differently estimated benefit analysis allows a triangulation (chapter 6.4).

Productivity by Yield

Income for households in Tajikistan depends largely on remittances and (near-)subsistence farming. Especially, poor households are restricted to immediate profit from crops (FAO and Ministry of Agriculture, 2011). Yield is therefore an important on-site effect to ensure livelihood through sustainable farming.

A yield questionnaire was created by Studer (2014), to assess the yield at plot level (Annex 1). Family size, cropland type, size and steepness of the plot, internal and external labour input, agricultural input and yield were assessed. For the latter product type, amount, market price per kg and the sold amount were listed. The yield survey was conducted in August and September 2012 after harvest time for croplands and orchards. The questionnaire was not used for pastures.

The goal of the survey was a monetary comparison between input and output, to analyze profitability of and between the study plots.

Soil quality by soil organic carbon

Soil quality is the capacity of soil to supply economic goods and services and maintain environmental functions (Pulido-Fernández et al., 2013; Wolfgramm, 2007; Lal, 1997). Depending on the vegetation cover and land use practice, SOC serves as an adequate on-site indicator for the soil quality of the plots.

In September and October 2012, PhD and Master students from the Centre for Development and Environment (CDE), University of Bern, Switzerland, carried out a soil sampling campaign in Muminabad. The aim was to build a soil spectral library to assess and monitor soil quality. The assessment helps to understand the impact of land use practices on soil quality. The sampling area included the Obishur and Chukurak watersheds with the six comparative studies and surrounding plots. 420 samples were collected from the study plots, at soil depths of 0-5, 5-30 and 30-50 cm (Table 3). The organic content of the soil samples was analyzed as well as total carbon, nitrogen and sulfur.

Table 3: SOC sampling design for the study plots with CP and SLM technologies.

land use	management practice	total sites	plots per site	depth	total samples
orchard	CP	2	14	0-5; 5-30; 30-50	84
	SLM	2	14	0-5; 5-30; 30-50	84
cropland	CP	2	9	0-5; 5-30; 30-50	54
	SLM	2	9	0-5; 5-30; 30-50	54
pasture	CP	2	12	0-5; 5-30; 30-50	72
	SLM	2	12	0-5; 5-30; 30-50	72

Runoff by Curve Number

Land use and practices have a big influence on runoff behaviour (Huang et al., 2003; Kosmas et al., 1997). No runoff data are available from the study area, thus modeled data had to be considered (personal consultation Caritas 2012). To estimate differences in runoff between the paired case studies the runoff curve number (CN) method was used (USDA SCS, 1986).

CN depend on soil and cover conditions. The soil and cover conditions are estimated for spring time. This study focuses on spring as it is the season with frequently occurring floods and mudflows in Muminabad. Figure 7 shows the procedure to assess the CN of a plot, passing through defined indicators, which are separately described below:

- Antecedent runoff condition (ARC)
- Cover type
- Cover treatment
- Hydrologic condition
- Hydrologic soil group (HSG)

The antecedent runoff condition represents the intensity and duration of rainfall, the total amount of rainfall, soil moisture conditions, cover density, stage of growth and temperature. Of the three classes - dry, average and wet conditions – the average and wet ARC (ARC II and ARC III) are considered in the study to calculate the corresponding CN II and CN III.

Cover type by the technical release of USDA SCS (1986) represents the crop type. The standard cover type was extended by mixed land use practices (agroforestry and silvopastoralism) being at the interface of two separate cover types (Figure 7). These cover type classes were used for CN calculation and averaged to get CN for the mixed methods.

The study plots were classified into:

- Small grain; for wheat and fodder grain
- Close-seeded or broadcast legumes; for perennial crops as Esparcet and Alfalfa
- Pasture, grassland or range; for pastures
- Woods-grass combinations; for orchards
- Small grain and wood-grass combinations; for agroforestry
- Wood-grass combinations and pasture, grassland or range; for silvopastoralism

Cover type can be differently treated. Cover treatment is the way cultivated agricultural land is managed. It involves management practices (no-tillage, cropland rotation) and mechanical practices (cropland residue, vertical or contour ploughing, terracing) and their combinations.

Cover type and cover treatment influence the hydrologic condition. The hydrologic condition represents the effect of cover type and treatment on infiltration and runoff capacity. It is estimated by the vegetation density and canopy and residue cover in the studied plots. Although the cover type and treatment do not change throughout the year, the hydrologic condition may vary seasonally. The density of vegetation cover depends directly on the cultivation cycle of planting and harvesting of crops. Studied plots can be classified into poor and good hydrologic condition, for orchards and pasture an additional fair condition is proposed by the technical release. To adjust the classification of all cover types into hydrologic condition, a fair hydrologic condition was introduced for all cover types. The fair condition represents the average CN between the poor and the good condition.

Vegetation cover and canopy in spring season could not be directly assessed on the studied plots, as field work was carried out in September 2012. In order to determine the vegetation cover in spring time for the required hydrologic condition an additional calculation had to be conducted. With this aim the cover percentage from September was assessed in field and calculated with a vegetation cover ratio, derived from Bühlmann (2006). Cover percentage was estimated using a 1 m^2-grid on the studied plots in Muminabad. Pictures of the grids were taken, and categorized into four classes according to their cover percentage. In every cropland and orchard five grids were placed and subsequently averaged. Eight grids were used in the pastures, to account for the big extent and heterogeneity within the plot. The grids were positioned randomly in order to represent the cover percentage of the studied plots. Classes were adapted from USDA SCS (1986) by adding a lowest cover percentage class, with finally < 25 % for very poor, 25 – 49 % for poor, 50 – 75 % for fair and > 75 % for good vegetation cover.

A cover ratio based on data by Bühlmann (2006) was created to estimate vegetation cover in spring using canopy cover (CC) data of annual cover sequences for distinct land use types from Faizabad, western Tajikistan. Bühlmann (2006) assessed the variability of vegetation cover per half-month and per land use type. The vegetation cover percentages from the months of April, May and September were used to create a ratio based on data from Faizabad. This ratio allowed reconstructing the vegetation cover in spring, after the assessment of vegetation cover in September in Muminabad. Equation 4 shows the derivation of the ratio between the average CC from the spring months of April and May and the average CC of September in Faizabad. The assessed vegetation cover per land use type in September in Muminabad was multiplied by the ratio derived from Bühlmann (2006) to estimate vegetation cover in spring.

$$\text{Ratio}=\frac{\dfrac{(\boldsymbol{CC}April\ (p\,1)+\boldsymbol{CC}April\ (p\,2)+\boldsymbol{CC}May\ (p\,1)+\boldsymbol{CC}May\ (p\,2))}{4}}{\dfrac{(\boldsymbol{CC}Sept\ (p\,1)+\boldsymbol{CC}Sept\ (p\,2))}{2}} \qquad \textbf{Equation 4}$$

With the average canopy cover in April and May (CCApril(px) and CCMay(px)) and average canopy cover in September (CCSept(px)) for the half-months (P1 and P2 respectively) of April, May and September (Renard et al., 2007 and Bühlmann, 2006).

According to the ratio, vegetation cover in spring (compared to September) is 25 % higher for pastures (with ratio 1.25), 21 % higher for small grain croplands (with ratio 1.21), 13 % higher for perennial grasses (with ratio 1.13) and 23 % higher for intercropped orchards (with ratio 1.23).

The HSG depends on the surface and subsurface infiltration and permeability rate respectively. The classification into the four HSG groups A, B, C and D is determined by the least transmissive soil layer and the depth to any permeable layer. For the moderately to heavily loamy soil in Muminabad (Sosin, 2012) group B was selected. The same HSG was considered for the hydrologic analysis by Vlieghe (2012). This soil group has relatively low runoff potential when wet. Water is easily transmitted through the soil.

Finally, for each of the plots a CN was defined after the classification of cover type, treatment, and hydrologic condition, considering the average runoff condition (ARC II) and the hydrologic soil group B (Figure 7). For mixed land use practices being at the interface of two cover types, the CN of both types was averaged and used for calculation.

For several study plots classification was not obvious and subjected to visual observations. Especially, the hydrologic condition could not be clearly classified, as it is based on multiple factors. Therefore a worst and a best state of every case study in doubt was defined, resulting in two distinct curve numbers attributed to the same plot in. The highest and lowest possible CN was averaged and used for further runoff calculations.

USDA SCS (1986) does not consider slope in the standard CN method even though inclination influences runoff behaviour greatly. Especially steep slopes contribute to a reduction of the initial abstraction, recession time and infiltration, all of them increasing runoff (Huang et al., 2006). For this reason the factor slope α [%] is incorporated into the curve number method by the following equation of Huang et al. (2006):

$$CNII_{\alpha} = \frac{1}{3}(\mathrm{CNIII} - \mathrm{CNII})(1 - 2e^{-13.86\alpha}) + CNII \qquad \textbf{Equation 5}$$

With *CN II* being CN for ARC II, and *CNIII* being CN for ARC III and α as slope in [%].

Cover type													
	Close seeded or broadcast legumes			Fallow		Small grain (Agroforestry)						Wood-grass combinations (Agroforestry / Silvopastoralism)	Pasture, grassland or range (Silvopastoralism)
Cover treatment	Straight row	Contoured	Contoured & terraced	Bare soil	Cropland residue cover	Straight row	Straight row & residue cover	Contoured	Contoured & residue cover	Contoured & terraced	Contoured, terraced & residue c		
Curve Numbers for hydrologic soil group B													
Hydrologic condition: Poor	77	75	73	86	85	76	75	74	73	72	71	73	79
Hydrologic condition: Fair	74.5	72	70	86	84	75.5	73.5	73.5	72.5	71	70	65	69
Hydrologic condition: Good	72	69	67	86	83	75	72	73	72	70	69	58	61

Figure 7: Procedure for selecting curve numbers for the hydrologic soil Group B and ARC II, by determining cover type, cover treatment and hydrologic condition. Adapted after USDA SCS (1986)

Runoff Q [mm] is derived from the USDA SCS runoff equation:

$$Q=\frac{(P-0.2S)^2}{P+0.8S} \qquad \textbf{Equation 6}$$

For $P > 0.2\,S$, with P [mm] as rainfall and S [mm] as potential maximum retention.

S is a parameter for soil, vegetation, land use and soil moisture conditions, before a rainfall occurs. Equation to assess S is:

$$S=\frac{25400}{CNII_{\propto}}-254 \qquad \textbf{Equation 7}$$

With CNIIα being curve number with slope.

Integrating S (Equation 7) in Equation 6, Q is expressed in the following runoff equation:

$$Q=\frac{(P-0.2\left(\left(\frac{25400}{CNII\ _{\alpha}}\right)-254\ \right))^2}{P+0.8(\left(\frac{25400}{CNII\ _{\alpha}}\right)-254\,)} \qquad \textbf{Equation 8}$$

Q calculated per each study plot allows to compare difference in runoff generation and to build scenarios for runoff reduction on watershed level (chapter 5.5).

Benefits determined using the WOCAT classification

WOCAT allows a qualitative assessment of the benefits. Part 3 of the QT analyses on- and off-site benefits and on- and off-site disadvantages of SLM technologies. In this study, the analysis will be extended to SLM technologies and CPs. Benefits and disadvantages concerning runoff reduction, productivity and soil quality were selected for the assessment.

For SLM technologies, chapters 3.1.1 and 3.1.2 from the WOCAT QT are considered. Whereas subchapter 3.1.1.1 concerns productivity, the ecological benefits (in subchapter 3.1.1.3) partly relate to soil quality and runoff reduction. Selected off-site benefits (chapter 3.1.2) are added to runoff reduction.

For CPs chapters 3.1.3 and 3.1.4 in the questionnaire are representing the disadvantages used for the assessment. Identically as for the benefits, subchapter 3.1.3.1 relates to productivity and sub-chapter 3.1.3.3 to soil quality and runoff reduction. Chapter 3.1.4 assesses off-site disadvantages, whereof some points are included in the assessment of runoff reduction.

The impact of the benefits and disadvantages is quoted as negligible (0 - 5 %), little (5 – 20 %), medium (20 – 50 %) or high (> 50 %) and ranked from 1 (negligible) to 4 (high). Benefit classes have a positive sign and disadvantage classes a negative sign, which is +4 and -4 for a high positive and negative impact respectively. The sum of the benefits and disadvantages for productivity, soil quality and runoff reduction are multiplied by one third to give each factor the same weight for the total sum. The total sum shows how beneficial or disadvantageous the SLM technology and the CP are concerning runoff reduction, productivity and soil quality.

A total of 33 benefits and 26 disadvantages were selected from the WOCAT questionnaire covering productivity, soil quality and runoff reduction. For productivity 15 benefits and 12 disadvantages, for soil quality 7 benefits and 5 disadvantages and for runoff reduction 11 benefits and 9 disadvantages were selected. For each study plot the observed benefits and disadvantages were matched with a ranking of their impact. The sum of the benefits and disadvantages per indicator was divided by three to give the same weight for each indicator.

Soil quality by visual field assessment

Land use alters runoff behaviour and soil quality (Kosmas et al., 1997). In order to improve land use practices a reliable tool is needed to understand mechanism and to make decisions. Shepherd and Jannsen (2000) propose a visual soil assessment (VSA) tool to evaluate mainly the physical and biological properties of soil.

The VSA allows a reliable, quick and cheap analysis, which was a precondition for the field analysis in Muminabad. Field indicators, proceedings and classifications were used from the VSA by Shepherd and Jannsen (2000) and Gasser (2009).

Following indicators were considered in the field assessment (Annex 2):

- Soil erosion: Assessment of the plot affected by erosive processes as mass movements, gullies and rills.
- Surface relief: Indicates the roughness or smoothness of soil respectively and indicates structural damages. It influences surface water storage capacity and in consequence runoff behaviour.
- Surface erosion: The loss of topsoil affects fertility and is classified according to the manual of Prasuhn and Fischer (2007).
- Soil compaction: Compaction is the counterpart of soil porosity. A compacted soil affects the vegetation growth due to hindered root development and diminished air and water storage in the soil. Soil compaction enhances soil erosion and affects productivity negatively.
- Vegetation cover: Vegetation cover prevents from several types of erosion, and reduces the disposition of crusting and drying out.

Soil erosion, surface relief and surface erosion, were visually assessed and categorized. The visual scoring categories are divided into three classes (Table 4): Class 1 for poor, class 2 for fair, class 3 for good soil properties.

Soil compaction was assessed by the knife test. A Swiss army knife was pushed into the corners and into the centre of the $1m^2$-grid and classified according to the reached depth. If resistance was high and the knife was only able to penetrate the soil for a few millimetres, the soil was categorized to be of poor quality. At a depth of around a centimetre soil was classified as fair, and if the knife penetrated deeper than one centimetre it was classified as good. As far as possible, furrows from ploughing were avoided during the knife test, since they would have biased the outcomes.

Vegetation cover was estimated with the 1 m^2 -grid, used as well for CN determination (chapter 5.4.2). A picture was taken and classified into three cover classes like in the CN Model (USDA SCS, 1986) To make classification simple, vegetation cover was reduced to three classes, as seen in Table 4. Good condition signified a vegetation cover over 75 % within a grid. A vegetation cover of 50 to 75% was classified as fair and below 50% as poor.

The scoring-categories of each indicator were adjusted from the VSA and (Gasser, 2009) to the local conditions.

Table 4: Indicators, methods and categories for the visual field assessment.

		Categories of soil quality		
Indicator	**Method**	**Good**	**Fair**	**Low**
Soil erosion	Visual assessment	<25%	25-50%	>50%
Surface relief		Smooth, unbroken	Broken up, penetrated	Deeply broken, penetrated
Surface erosion		Light	Moderate	Strong
Soil compaction	Knife test	>cm	~ cm	mm's-mm
Vegetation cover	Picture estimation	>75%	50-75%	<50%

Each indicator of the visual classification was ranked and averaged per plot to give a final category. The taken knife tests of each plot were averaged and classified into a category. Same procedure was done for the vegetation cover. With the attributed number per category, an average was calculated for each study plot and interval scaled for the categorization.

5.4.3 Synthesis of the benefits and triangulation

The aim of the synthesis is to compare the benefits. Productivity, soil quality and runoff will be compiled by means of spiderwebs. For this purpose, the results of each benefit per study plot will be classified into three categories by interval scaling. The categories represent low, fair and high beneficial impact, which are numbered from 1 to 3. This classification allows building spiderwebs, to compare and to illustrate the impact of benefits of the study plots. Furthermore, triangulation of the different methods is made possible.

5.5 Runoff Reduction Scenarios

Runoff reduction scenarios aim to extrapolate runoff reduction from plot to watershed scale. As the study area focuses on the middle zone of the Obishur and Chukurak watershed, scenario building will be considered for the same area. Neither runon coming from the upper zone nor the effective runoff volume reaching the lower zone of the watersheds will be considered for the scenarios. The scenarios are limited to the generated runoff volume by the three main land use types – pastures, orchards and crops - in the middle zone.

The total area of the three major land use types and the extent of use of CP and SLM technologies, per land use type is not known. Consequently, the area had to be determined using Caritas reports and proportion classes created. Four proportion classes ranged from only CP and no SLM technologies up to no CP and only SLM technologies, with evenly. As schematically shown in Figure 8, the best case scenario is the full implementation of SLM technologies in the total area of a land use type. In the worst case only CPs are applied instead of SLM technologies, in the whole area.

The land use and watershed specific scenarios are based on the documented study plots. For example, in a best case scenario, the whole cropland in the middle zone is considered to have the same runoff rate per ha as the corresponding study plot of SLM crop in the same watershed. In a worst case, the total cropland area generates the runoff rate per ha as the study plot of the CP crop does.

The difference in runoff volume of the worst case and another case shows the saved runoff volume. The highest potential runoff reduction is the runoff difference between the worst and best case scenario. In consequence, runoff difference represents the runoff reduction volume when SLM technologies of a certain proportion are implemented.

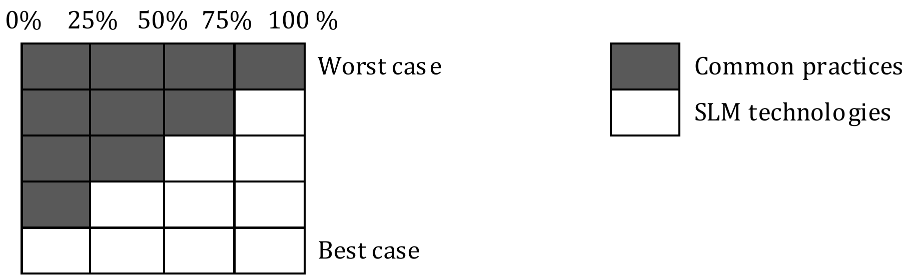

Figure 8: Scheme for scenario building depending on the area percentage of CPs and SLM technologies respectively: Ranging from the worst case scenario (with 100 % of CP and no SLM technologies) and the best case scenario (with 100 % of SLM technologies and no CP). In between two additional combinations of percentages (25 and 75%) by CP and SLM technologies serve as the basis for scenario building.

6 RESULTS AND DISCUSSION

6.1 Study plots

According to the research approach in chapter 4.3, six comparative studies of twelve study plots were identified per watershed. A CP and a corresponding SLM technology per land use type, defined as a comparative study were selected. Given the focus on pastures, orchards and croplands, three comparative studies were identified per watershed. Figure 9 and Figure 10 show the selected plots and comparative studies for the Obishur and Chukurak watershed respectively. Some identified plots are located outside the middle zone and border of the watershed. The reason for choosing plots outside of the zone is the unavailability of an land use practices inside the middle zone. Moreover, pre-existing contacts to farmers led to prioritizing of specific study plots even if they lied outside the borders. As physiographical similarities between the paired plots were maintained, these dislocated study plots did not additionally affect the comparability.

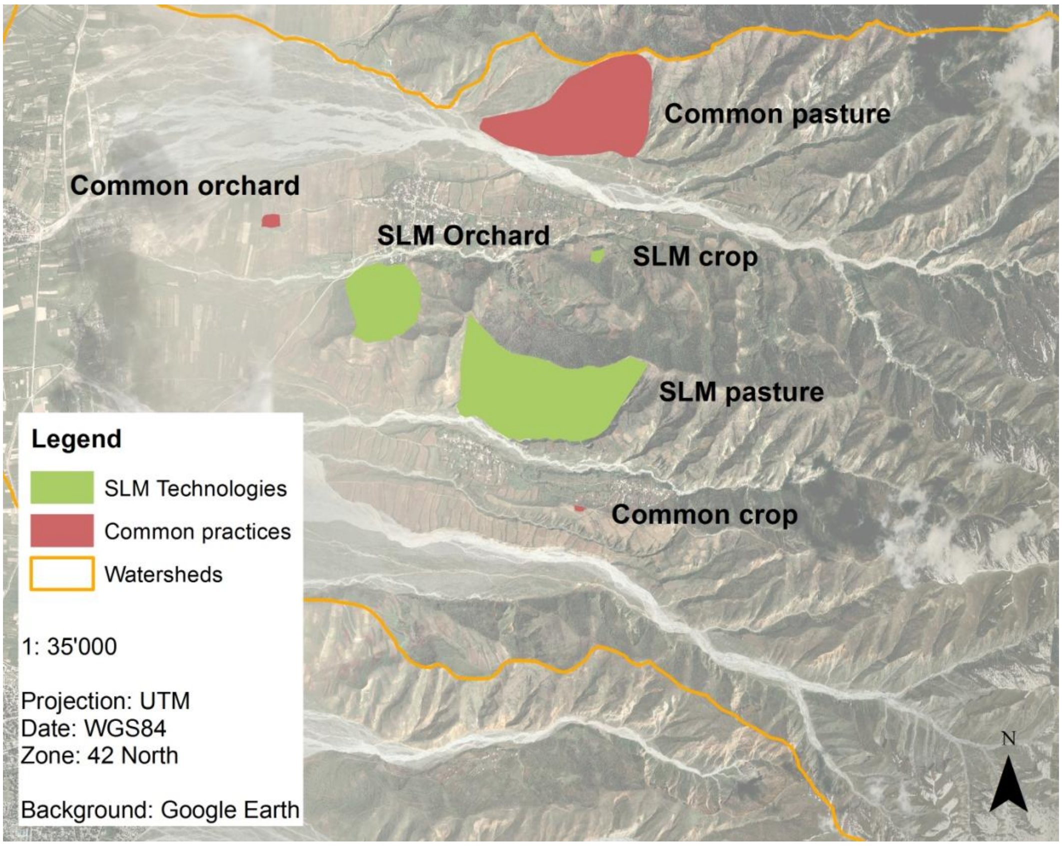

Figure 9: Location of the CPs and SLM technologies within the Obishur (Google Earth 2003, 2006)

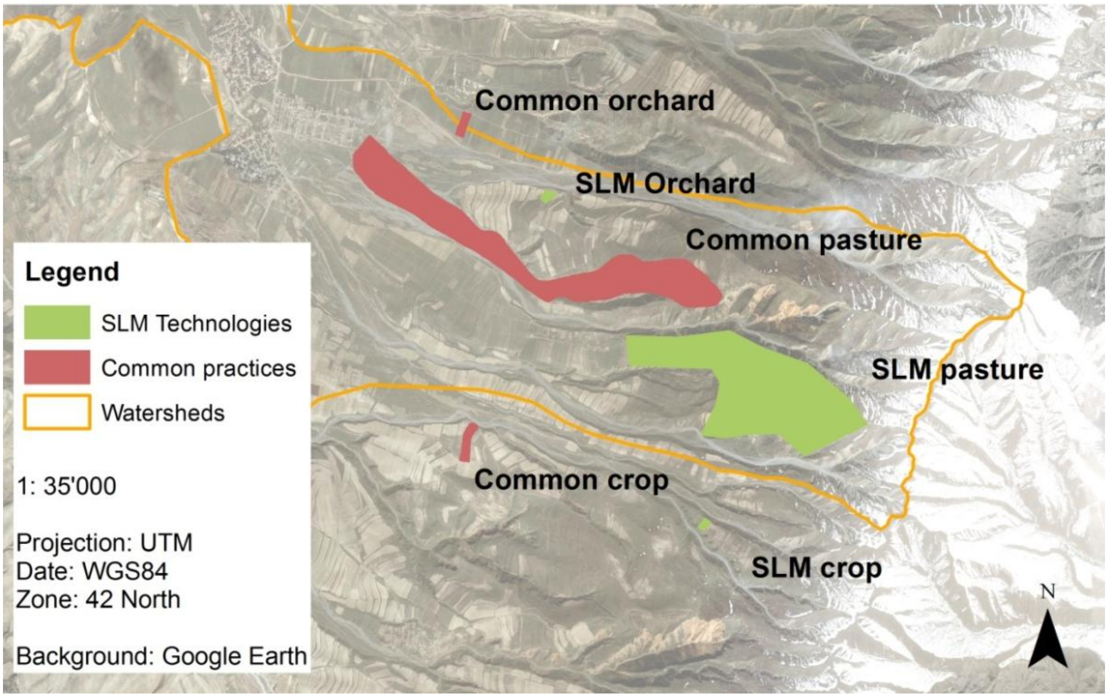

Figure 10: Location of the CPs and SLM technologies within the Chukurak watershed (Google Earth 2003, 2006)

In total twelve plots were documented with the WOCAT QT. The SLM technologies are published and accessible on the WOCAT online data base.[4] Table 5 shows a compilation of the documented study plots of CP and SLM technologies from both watersheds.

[4] www.wocat.net.

Table 5: Selected cases studies per watershed, divided into land use type and land use practice with the corresponding WOCAT code, with CP= Common practices and SLM= SLM technologies. Description is slightly shortened from official titles by WOCAT.

			Description	WOCAT Code
Obishur	**Pasture**	**CP**	Degraded communal pasture	*T_TAJ046*
		SLM	Pasture management trough rotational grazing	*T_TAJ048*
	Orchard	**CP**	Current agroforestry: orchard with wheat intercropping	*T_TAJ049*
		SLM	Silvo-pastoralism: Orchard with integrated grazing and fodder production	*T_TAJ044*
	Cropland	**CP**	Feed grain cultivation	*T_TAJ050*
		SLM	Orchard establishment on former wheat crop	*T_TAJ047*
Chukurak	**Pasture**	**CP**	Degraded communal pasture	*T_TAJ045*
		SLM	Pasture management of a communal grazing land	*T_TAJ051*
	Orchard	**CP**	Current agroforestry of an orchard with wheat intercropping	*T_TAJ052*
		SLM	Mixed fruit orchard with intercropping of Esparcet and annual crops	*T_TAJ043*
	Cropland	**CP**	Wheat crop in rotation with chickpea	*T_TAJ053*
		SLM	Crop rotation including annual crops and Esparcet	*T_TAJ054*

6.1.1 Common Practices

The communal pastures of Chukurak and Obishur were classified as CP since they showed gullies, rills, logging, and a sparse vegetation cover due to trampling and overgrazing. Awareness and interest by the owners of the plots regarding the on-going degradation seemed to be limited.

A sustainable development of pastures is hindered by the lack of organized grazing and low pasture use fees. Both orchards used with CPs were established a long time ago. The fruit trees are more than 20 years old, neither pruned nor fenced in both watersheds. The rows show gaps where dried up trees were removed. The orchards have been intercropped with wheat in recent time, which reflects the abandonment and degradation of the orchards. The farmers claimed that the orchards generate only a low harvest. Maintenance activities are high compared to the output, which may explain the perceived loss of interest by farmers. Feed grain and wheat are cultivated on the rain-fed cropland in Obishur and Chukurak watershed. Vertical and contour ploughing is applied. Both croplands show rill erosion with a low vegetation and low mulch cover. As long straw is needed for the cows and yield is enough to feed the families, the farmers do not see reasons to change neither crop type nor land use practice. The CP documentations are listed in Annex 3.

6.1.2 Sustainable Land Management technologies

The SLM technologies in the Obishur and Chukurak watershed were selected by means of the visual indicators listed in chapter **Error! Reference source not found.** and by indications f the staff of Caritas Switzerland in Muminabad. Good conservation measures are limited in the area due to lack of knowledge, institutional and financial support for the rural community (chapter 2.1). However, innovative, personally committed and conscientious farmers exist, who established SLM technologies in the watersheds. Many of them claimed to have been inspired or supported by Caritas Switzerland.

However, the choice of suitable SLM pastures turned out to be difficult. Although visually the SLM pastures did not differ greatly from the CP pastures, they showed management patterns which were missing in the CP pastures. Both SLM pastures are based on rotational grazing. The SLM pasture in Obishur demands fees for grazing. The SLM pasture in Chukurak works on the community level, where every family of the village is involved in the execution of rotational grazing. The SLM orchards are combined with another land use type, being examples of a local agroforestry and silvo-pastoralism system. Grazing and haymaking amend the SLM orchard Obishur, in the Chukurak watershed the orchard is intercropped with chickpea. Both orchards are fenced and guarded. The fruit trees are regularly maintained by pruning and soil loosening around the stem. Vegetation cover of the SLM orchards is high and medium in Obishur and Chukurak. No or few signs of erosion were observed. Perennial grasses are cultivated on the SLM croplands which are guarded and fenced. Vegetation cover was important with marginal rill erosion on the plots.

The six selected SLM technologies in Muminabad are detailed in Annex 4 and briefly described below:

T_TAJ043: Mixed fruit tree orchard with intercropping of Esparcet and annual croplands

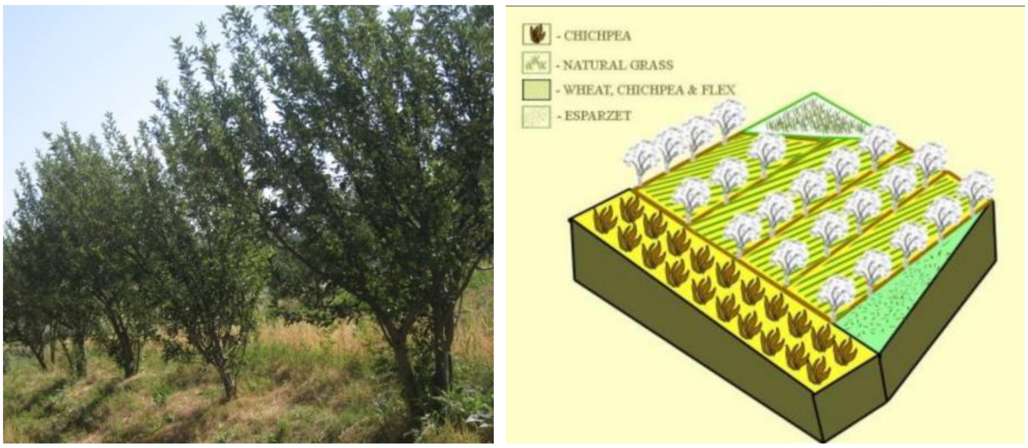

Figure 11: Orchard based agroforestry established on the hill slopes of Muminabad (left) with the technical drawing of the SLM technology (right) (picture and drawing: Q. Shokirov).

Between 1993 and 94 an individual farmer initiated an orchard by planting a mix of fruit trees, such as apricots, walnuts, cherries, almonds and mostly apple trees in the rain-fed hill zones of Muminabad District. The total area of the plot is 1.03 hectares, whereof 0.60 hectares are orchard, Esparcet is covering roughly 0.30 hectares, 0.07 hectare is for haymaking and the rest of the 0.06 hectares is used for growing chickpea and wheat.

Shortly after the fall of the Soviet Union, the government officials distributed land to the villagers. The farmer always had a big interest to establish a small orchard and he obtained little more than a hectare of land. It is his project for retirement. According to the farmer, the first two years were very crucial and labour intensive for the whole family. At the beginning boars ate many of the planted vegetables and melons. Consequently the idea came up by the farmer to install a fence around the plot and introduce Esparcet intercropping.

T_TAJ044: Silvo-pastoralism: Orchard with integrated grazing and fodder production

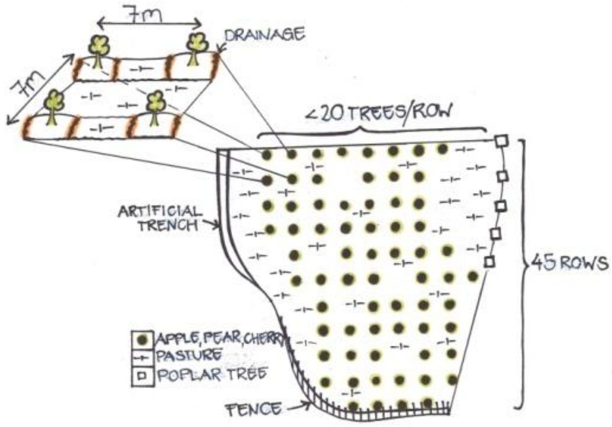

Figure 12: Apple trees in front with the farmer's house in the background (left) with the technical drawing of the SLM technology (right) (picture and drawing: own elabouration).

In Soviet times, the total area of 40 ha comprised terraces and walnut trees in the steep foothills and pastures in the lower and flatter part. After the collapse of the Soviet Era, many similar areas got degraded due to uncontrolled grazing and overuse of natural resources. The area was taken over by a family in 1991. Within the whole property, roads were built to improve the access. Additionally 6000 trees were planted, whereof 1200 fruit trees were planted on the pasture, converting it into an orchard by silvo-pastoralism. At present, the 6 ha of orchard are mainly consisting of three types of apple (white, golden and red), some pear and cherry trees, as the farmer counts currently around 1000 fruit trees. The farmer let his livestock graze in the orchard, and cuts the remaining grass in autumn, if there is still left. The integrated orchard with pastureland and fodder production is partially fenced to hinder livestock entering his property. Furthermore, the orchard is within the range of vision which allows the farmer`s family to guard it.

The farmer who is managing the orchard today obtained the property of his father in order to continue the family project by his own initiative. By farming he ensures the livelihood of his family. Hence, he felt responsible to progress and improve the quality of life of his own family. The main reason for establishing the orchard within the grassland and to install fences, was to increase productivity of the land, by bringing along beneficial effects on soil quality. Furthermore he provides the local market with food products.

T_TAJ047: Orchard establishment on a former wheat plot, by planting fruit tree seedlings in combination with sowing Alfalfa

Figure 13: Fenced Alfalfa at the early stage of orchard establishment (left) with the technical drawing of the SLM technology (right) (picture and drawing: own elaboration).

In 2009 the farmer changed his wheat plot into an Alfalfa plot where he also planted fruit tree seedlings in between to establish an orchard. One hectare is used for the perennial cropping of Alfalfa. Alfalfa cropping supplements beneficial soil functions, which are crucial for the establishment of an orchard. The plot lies on a narrow plateau next to other wheat croplands. Fruit and nut orchards on a gentle slope and a steep slope of the riverbed border the plot. A solid fence prevents boars from entering the area through the nut orchard. The plot is not accessible by the steep slope. Two fences are built from the side of the neighboring wheat plots. One fence works like an entrance gate to all the plots on that plateau. A second fence indicates the boundaries between the farmers' Alfalfa cropland and the wheat plots belonging to other farmers. The whole family is working on the farmland, consisting of several plots, which are distributed over the valley.

In order to establish an orchard, the farmer first planted Alfalfa, which maintains more moisture in the soil and hence creates favourable conditions for tree growth. The wheat croplandping was drying out the soil. Therefore during heavy rainfall events water infiltration was limited, and the strong runoff washed away the wheat cropland. It was the farmer’s initiative to change the land use practice of the crop, but Caritas Switzerland supported him with a financial grant. Alfalfa can be harvested several times a year, which he can use as fodder for the livestock or as cash cropland.

T_TAJ048: Pasture management through rotational grazing

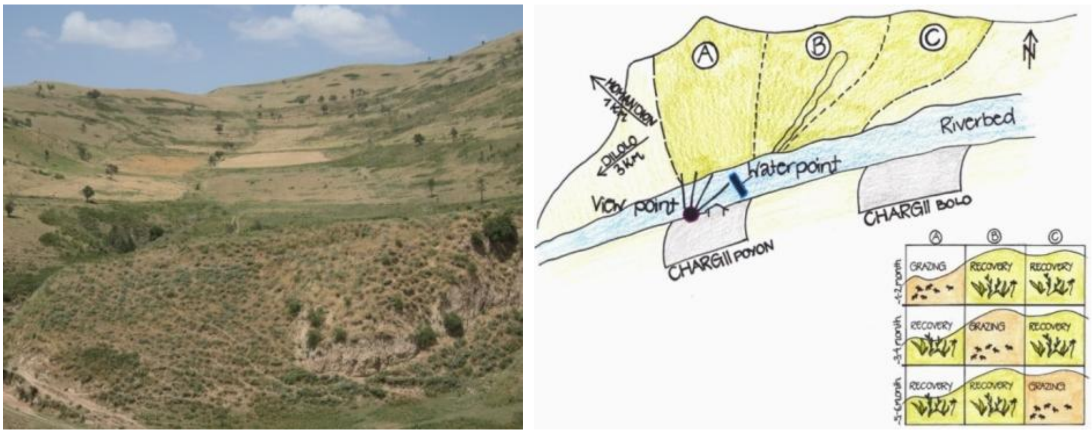

Figure 14: Rotational grazing on private grazing land used as daily pastures (left) with the technical drawing of the SLM technology (right) (picture and drawing: own elabouration).

A riverbed divides the pasture where rotational grazing is practiced with the village Chargii poyon, where the certified land user and owner of the pasture lives. From a view point nearby his house, he has a good view on and hence a good control over the pasture area. This allows him to keep intrusive livestock outside, having a limited number of grazing livestock in the pasture. The area encompasses 119 ha, from which 5 ha are rented out as cropland land.

Land tenure conflicts existed about this pasture over many years, because there was no owner declared. The certified land user of Chargii poyon claims to possess the pasture since 1999. It is unclear how he got the land transferred. Being aware of the ongoing degradation of this land, the certified land user divided the area into 3 parts and introduced controlled grazing in 2007. The pasture is guarded by him and 4 more people to avoid that intrusive livestock enter. While one part is being grazed the other two are resting. After one to two months of grazing on a part, the herds move to the next part. The rotation phases depend on the availability of grass. At the moment of documentation in June 2012, there were 145 cows and some 30 goats and sheep. The number of animals is varying seasonally, with more animals in summer than in winter. It can be explained by a better grass availability of this pasture comparing to others in summer.

The farmer learned in a seminar organized by Caritas Switzerland about increasing productivity of pastures by a prolonged duration of time for vegetation recovery. This convinced him of the idea of pasture rotation. The main reasons for changing the pasture management were the advanced stage of deforestation, increasing overgrazing, and the additional source to get the land taxes paid. The management of the pasture by rotational grazing on three parts allows the non-grazed parts to rest and recover. Less grazed and trampled areas result in increased vegetation cover and thus fodder quality, as well as increased soil stability and thus a reduced risk of disasters, such as floods.

The farmer expected that the implementation of land conservation measures would stop the on-going pasture degradation and would assure long-term and sustainable use of the land. Despite the rotating system, the grazing land is still overgrazed and shows signs indicating medium erosion, but less than other pastures in the watershed. The area being the most far away from the settlement is in best condition. The closer to the riverbed the more degraded and eroded the pasture is. Nevertheless, additional measures are necessary to reduce soil erosion and gully formation in the area. The farmer would like to invest into the pasture by planting trees and building another water point in order to decrease livestock pressure punctually.

Livestock owners pay fees to the farmer only for grazing cows, not for sheep and goats. The amount of the fee for grazing depends on the provenance of the herder. Fees vary greatly between the villages.

T_TAJ051: Pasture management of a communal grazing land

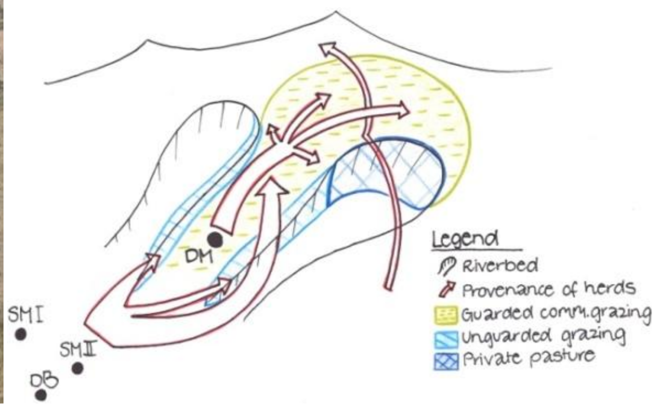

Figure 15: View on the pasture from above (left) with the technical drawing of the SLM technology (right) (picture and drawing: own elabouration).

The total area of the pasture accounts around 300 – 500 ha. The pasture is property of the Doshmand village but it includes also some private properties, mainly potato and wheat croplands. After the harvest, livestock is also grazing on these croplands. Eighteen households are using the pasture with totally 150 cows and 500 small animals currently. Additionally, three groups of herds from other villages graze irregularly on this pasture mainly on the lateral parts as it is less guarded by the villagers. The interviewee estimates over 1000 cows, goats and sheep that are in totally coming from other villages. Other herds cross this pasture when going or coming back from the summer pasture in spring and autumn respectively. Nevertheless this intrusive grazing is accepted as “every animal has to be fed”, as Doshmand residents claim. This shows the need of a pasture management not only on village but on watershed level.

During Soviet time the inhabitants of Doshmand were forced to migrate to the valley. The resettlement of the ancient location started with two families in the year of 2003. The villagers took over the pasture in a healthy state. In order to conserve good condition, pasture management got established and family by family who resettled, joined that system. The controlled area is divided in 4 subparts, where the herd switches daily within these parts. Every household looks after the herd for a day, which gives a rotational cycle of 18 days. There are no fixed and regular meetings for pasture management within the village pasture. However the communication exists between two subsequent herders, to know where the herd has been grazing and where to graze as next.

Purpose of the rotational grazing is to graze on one subpart, while the three other parts are resting. This reduces the impact of grazed and trampled areas per subpart and allows grass to grow and recover in the other parts.

The task of herding is shared among the families. The rotational grazing is organized orally and freely, why it is not sure if that approach is strictly binding. Discussions about pasture management come up only in case of need.

T_TAJ054: Cropland rotation including annual croplands and Esparcet cultivation

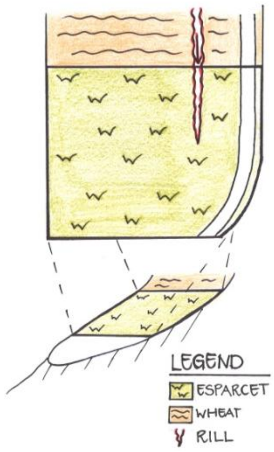

Figure 16: Perennial crops (left) with the technical drawing of the SLM technology (right) (picture and drawing: own elabouration).

An Esparcet plot of one hectare is growing on a hillslope in the Chukurak watershed. The owner lives in the valley far away from the plot. During the harvest, he is staying overnight for over a week in the hills, because a daily journey to his house would take too much time. For the last three years, the farmer is cultivating Esparcet with the main aim to feed his cows. In two years time, he will switch to wheat or chickpea. The farmer has 19 hectares of cropland in total, out of which the Esparcet plot accounts for 20% of his income. Next to the plot with Esparcet, other farmers grow wheat and chickpea. In comparison to Esparcet, those plots must be protected from boars. Even though irrigation is impossible and the water point is far away, Esparcet grows very well because of the straight and spread-out roots. Esparcet is beneficial to soil moisture, fertility and soil stabilization. Moreover, thanks to the cropland rotation, soil remains healthy.

The farmer stresses that good knowledge is needed to know where, what and how to cultivate. His main purpose for growing Esparcet is to have fodder for his cows. Yield quantity and quality are very satisfying for the farmer. Esparcet seeds are more expensive than wheat seeds, but also give a higher harvest. Furthermore, no fertilizers and guarding are needed. Esparcet can be harvested up to three times a year depending on water availability.

The SLM technologies above correspond to the proposed technologies selected during the SLM Decision Workshop in May 2012 in Muminabad. The SLM pastures show an added value not only in the state on the pasture through higher vegetation cover but also raises the awareness of local people that pastures have to be protected and management to avoid their degradation. The higher vegetation cover in the SLM pasture T_TAJ051 underlines the idea of tree and shrub plantation to reduce soil erosion, discussed in the workshop. Contour terracing as proposed technology during the workshop was illustrated by T_TAJ043, where terraces were built after years of contour ploughing. Difference between terracing and non-terracing could be even observed within the plot, as a part is not terraced. Rills showed up in the non terraced plot and vegetation cover was low. On the terraced part of the SLM plot less signs of erosion were observed. Perennial crops proposed in the workshop have big socio-economic and ecological potential. The SLM croplands T_TAJ047 and T_TAJ054 have benefits on soil moisture, water infiltration and storage capacity, but also give a very good harvest.

Some technologies proposed during the workshop in Muminabad are indeed linked to high labour and costly measures. But the selected SLM technologies reflect that through management, which do not demand more labour except dialogue, soil quality through raised vegetation cover can be assured on long term. A very useful approach listed in the workshop is to learn from the lessons, which addresses the local community and gives them responsibility to change the on-going degradation by themselves. A change in the depletion of resources should not rely on immediate, laborious and costly measures but on capacity building and awareness rising of the populace of Muminabad.

6.2 Costs

Establishment and maintenance costs of the land use practices were assessed with the chapters 2.5 and 2.6 of the WOCAT QT. Table 6 shows prices per unit in TJS and US$ for selected establishment and maintenance activities as well as inputs, mentioned by the interviewed farmers.

Table 6: Price list for agriculture related activities and inputs, information taken from the farmer interviews with WOCAT QT:

Activity / Input	Price [TJS] per unit	Price [US$] per unit
Fruit tree seedling	3-5/tree	1/tree
Tree pruning	3/tree	0.6/tree
Tree planting	3/tree	0.6/tree
Harvesting fruit tree	3.6/tree	0.8/tree
Transport renting (without fuel)	80/day~ 10/hour	16.6/day~ 2.1/hour
Tractor renting	~30/hour	~6.2/hour
Fuel	5.5/liter	1.1/liter
Fence (material: concrete pilar and wire)	18/metre	3.7/metre
Fencing (workload)	10.2/metre	2.1/metre
1 working day=8h	60/day	12.4/day

The price list shows approximate values. In fact, prices may vary according to specific measures or location of a plot and consequently, have to be considered with precaution. If not indicated differently by the farmer, establishment and maintenance costs were completed with prices from the list above.

For the calculations, a working day was defined as one person working eight hours a day. If the interviewee indicated exact working hours, they were divided by eight in order to achieve standardized working days. If the interviewee indicated a range of two values, to give an approximate workload, the values were averaged for further calculations, as in the following example:

> Interview statement: "A certain activity was done within five to six hours by two to three persons."
> WOCAT documentation: "5.5 hours by 2.5 persons are 13.75 working hours and 1.7 working days respectively."

The high costs of establishment, especially for orchards or croplands, may bias expenditures and make comparison difficult between the study plots in a short-term perspective of one year. To avoid this problem, costs are summed up with a long-term perspective of ten years. For the ten years perspective, the first year is considered as the establishment phase. The following years consist only of recurrent activities. The long-term annual total costs (TC) is consequently the sum of the establishment costs (EC) which were divided by factor ten and the annual maintenance costs (MC), as shown in Table 7. The SLM cropland Obishur, CP orchard Obishur and CP orchard Chukurak were partly subsidized in the establishment phase, as seen in the column of the subsidized total costs (STC). Establishment and maintenance activities for pastures consist only of labour input by organization and coordination on community level. The interviewees could not indicate the workload for the pastures which is why no expenditures are attributed to pastures.

As indication of the workload by the interviewees has been partly not verifiable, costs with labour input and without labour input are presented in Table 7. EC, MC, TC and STC are shown. Subsidies by the state or organizations for certain agricultural activities were subtracted from the total cost of a plot. The compilation of costs is only possible, if the documented maintenance activities are assumed to be constant year by year.

Table 7: Average annual costs in US$ per ha calculated on a long-term perspective of ten years including labour input (left) and excluding labour input (right) for each study plot. With Ob= Obishur, Ch= Chukurak Watershed, EC=Establishment costs, MC= Maintenance costs, TC= Total costs, STC= Subsidized total costs

[US$/ha/yr]	**Costs: including labour**				**Costs: excluding labour**			
Study plot	**EC**	**MC**	**TC**	**STC**	**EC**	**MC**	**TC**	**STC**
CP orchard Ob	81	785	866	*845*	31	213	244	*223*
CP orchard Ch	50	364	414	*380*	34	40	73	*40*
SLM orchard Ob	53	391	444	-	33	8	41	-
SLM orchard Ch	621	4626	5246	-	469	132	601	-
CP cropland Ob	0	1495	1495	-	0	229	229	-
CP cropland Ch	36	426	462	-	13	190	203	-
SLM cropland Ob	331	2613	2945	*2742*	227	0	227	*88*
SLM cropland Ch	23	1282	1305	-	22	108	130	-

Costs vary greatly depending on land use type and land use practice.

- Including labour: Annual costs range from approximately 400 up to 6000 US$ per ha, when subsidies are not considered. In average, MC is higher by factor ten than the EC. In average costs of SLM technologies are three times higher than CP. Orchards cost slightly more than croplands
- Excluding labour: Annual costs range from 40 to 600 US$ per ha, without subsidized total costs. EC and MC are similar. The TC is comparable between the SLM technologies and CP.

Differences in TC are smaller when labour is not considered. TC including labour is by far greater than total costs excluding labour. In especially SLM technologies are very labourious, TC including labour by factor ten in comparison to TC excluding labour (SLM croplands). Subsidies were mainly received in the establishment phase of a plot.

During the interviews, the indication of the workload was partly very approximate and hard to comprehend. This is why working hours, working days, and the number of people working are often rough estimations.

It has to be considered that the duration of a working day is very individually perceived and so the actual working hours are not fully known. Additionally, the establishment phase of several CP and SLM technologies, especially orchards, are dating back over 20 years. For those practices, the number of people and working hours during the establishment phase remained imprecise and difficult to reconstruct. Comparisons and cross-checking with similar study plots were done if available and completed by consultations with Caritas Switzerland.

In the case of the SLM orchard Obishur (T_TAJ044), the initial costs include the orchard establishment, but also fencing, road construction and additional organizational changes within the whole property. The effective cost and labour input for the orchard could not be clearly separated from the overall costs. Therefore it is based on estimations and completed, as far as possible, with the information of other orchards.

Another matter of concern is the different age of the plots. Whereas some practices and measures were introduced in the early 90s others were recently established (e.g. T_TAJ047, T_TAJ047and T_TAJ054 respectively). This not only has consequences on the yield (chapter 6.2.1) but also on the cost calculation and the accuracy of the given information.

The high costs of orchards can be explained by the costs related to seedlings, tractor use for terracing and other agricultural inputs. SLM technologies are more costly on average as they include additional measures and activities compared to CP. Frequent and regular recurrent activities, such as pruning and guarding, and the installation of fences relate to SLM technologies are all factors that increase establishment costs.

6.2.1 Yield

The yield questionnaire designed by Studer (2014) aimed to document the harvested amount, the current prices per product and the proportion of cash and food crops of each study plot (Annex 1). Yield was assessed in autumn 2012 after harvest, showing one harvest season.

Figure 17 shows the assessed annual harvest for the orchard and cropland plots, divided into the proportion of market and subsistence products.

Perennial crops can be harvested two to four times a year, depending on water availability on the plot (Ruppen, 2012). Yield of perennial crops was only documented after the second harvest. If not indicated differently by the farmer, harvest was reconstructed according to consultation with Caritas as follows: the first harvest for perennial crops gives the maximum harvest, whereof 70% can be harvested the second time, 50% in a third harvest and 20% in the last harvest.

As the productivity of pastures could not be identified with the questionnaire, all pasture plots are excluded from the yield assessment. Wood production and collected leaves by orchards were not documented and therefore not considered in the assessment.

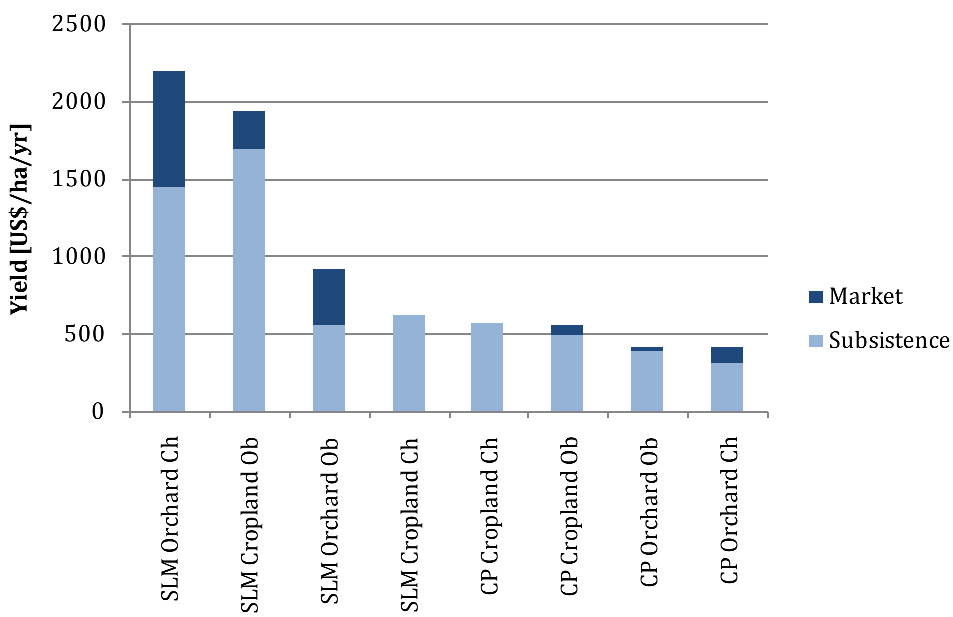

Figure 17: Annual yield per ha for each of the study plots (except pasture), ranged from highest to lowest yield divided into the proportion sold on market (market) and the proportion for self-supply (subsistence). Data were assessed after harvest period in August and September 2012.

Annual yield varies greatly between the studied plots (Figure 17). Minimal yield was slightly over 400 US$ for both of the CP orchards. The SLM orchard in Chukurak with over 2200 US$ of income recorded maximum yield. The average yield is three times higher for SLM technologies than for CP (1423 US$ per ha compared to 487 US$ per ha) after full establishment. The average annual yield by croplands is similar to the yield by orchards.

The amount sold on the market generally takes a small proportion of the total yield. The absolute amount of market product is higher for SLM technologies than for CP. Orchards have a four times more cash crops than croplands per ha. One third of the harvest by the SLM orchard Chukurak and the CP orchard Chukurak is sold on market, even if the total quantity of the CP orchard is much lower.

Several farmers claimed to have had lower yield in 2012 than usual, because of hail storms in spring and a long and rainy winter season (SLM orchard Obishur, CP orchard Chukurak). In case of an unsatisfying yield in 2012, the farmers indicated the amount they normally harvest. As the normal yield is based on rough indications, the effective yield from the harvest in 2012 was considered for the calculations.

The results underline that differences in yield are much more pronounced between land use practices than between land use types. SLM technologies show all a higher yield than the corresponding CP. In contrast, yields between orchards and croplands are similar. From this observation it follows that SLM technologies have a positive effect on productivity.

Inconsistent information was partly observed in the harvest assessment. The lack of representativeness makes comparison with additional literature indispensable. Table 8 compares the assessed yield with values from other literature.

Table 8: Amount of yield [kg/ha] for wheat, perennial crops and orchards in Tajikistan, compared with additional literature.

[kg/ha/yr]	Wheat	Perennial crops (dry matter)	orchards
FAO (2013)	1180-2590	2000-2500	-
Muminjanov (2008)	2300	2880	2250
Ruppen (2012)	1340	2600	10‘000*
Studer (2014)	2000	1250	-
Own assessment (2012)	1200-1375	1130-3210	500-530 (CP) 1200-1800 (SLM)

* with the assumption for 250 trees/ ha and 20 years old trees

Wheat production is similar to other sources, whereas the documented harvest of perennial crops is rather low from the assessment in Muminbad. The indicated yield of the perennial crops of other sources fit with the assessed range. However, a direct comparison of the harvested amount of perennial crops bears uncertainties. It is not known how many times the perennial crops were harvested in the other sources. The yield calculated in orchards in this study show very low values in comparison to the literature. Reasons other than low productivity are possible, as the tree type and tree density is not known of all the sources.

6.2.2 Net Profit

A net profit was assessed by compiling yield with the corresponding costs. Labour input was not included in the net profit calculations as this indicator was missing and partly untraceable causing difficulties of comparison as mentioned in chapter 6.2. Consequently, Table 9 consists only of hard costs from establishment and recurrent activities.

Cost and yield were calculated from a short-term and long-term perspective, assuming that costs and yield remain constant annually. The short-term analysis represents the establishment phase with the duration of one year. For the long-term perspective the MC of ten years were added to the EC. The result is divided by ten to give averaged annual costs for each study plot. With the assessed yield in the chapter above the net profit is calculated. The short-term and long-term net profit shows the difference between the yield and the costs in short- and long-term respectively.

The study plots have different ages and used a different duration for the establishment phase depending on land use type and land use practice. Usually, annual crops harvest after the first year, perennial crops harvest from the second year on, whereas orchards show yield after five years. Several agricultural activities and material are related to harvest. In order to avoid these differences and to raise comparability, all study plots are assumed to be fully established and are annually yielding from the first year on.

Table 9: Annual costs, annual yield and annual net profit on short-term (Establishment) and on long-term (Establishment & Maintenance) per study plot. Subsidized total costs and net profit are shown in parenthesis. Labour input is not included. With Ob= Obishur and Ch= Chukurak watersheds.

[US$/ ha/yr]	**Establishment (short-term, of 1 year)**			**Establishment & Maintenance (long-term of 10 years)**		
Study plot	Total costs *(Subsidy)*	Yield	Net profit *(Subsidy)*	Total costs *(Subsidy)*	Yield	Net profit *(Subsidy)*
CP Orchard Ob	311 *(100)*	-	-311 *(-100)*	244 *(223)*	410	166 *(187)*
CP Orchard Ch	336 *(0)*	-	-336 *(0)*	73 *(40)*	409	335 *(369)*
SLM Orchard Ob	332	-	-332	41	925	884
SLM Orchard Ch	4685	-	-4685	601	1552	952
CP Cropland Ob	229	559	330	229	559	330
CP Cropland Ch	190	569	4379	203	569	366
SLM Cropland Ob	2269 *(882)*	-	-2269 *(-882)*	227 *(88)*	1941	1714 *(1853)*
SLM Cropland Ch	219	-	-219	130	621	492

Establishment costs within the first year range from no money input (with subsidy), 190 US$ per ha (without subsidy) up to over 4000 US$ per ha. The only plots yielding harvest in the establishment phase are CP croplands. Consequently, CP crops show a slightly positive short-term net profit. In contrast, all the other plots are unprofitable in the first year. SLM orchards, CP orchards and SLM cropland show short-term no yield, but have high EC.

Long-term net profits are visualized in Figure 18 in order to improve the readability of the long-term calculations in Table 9.

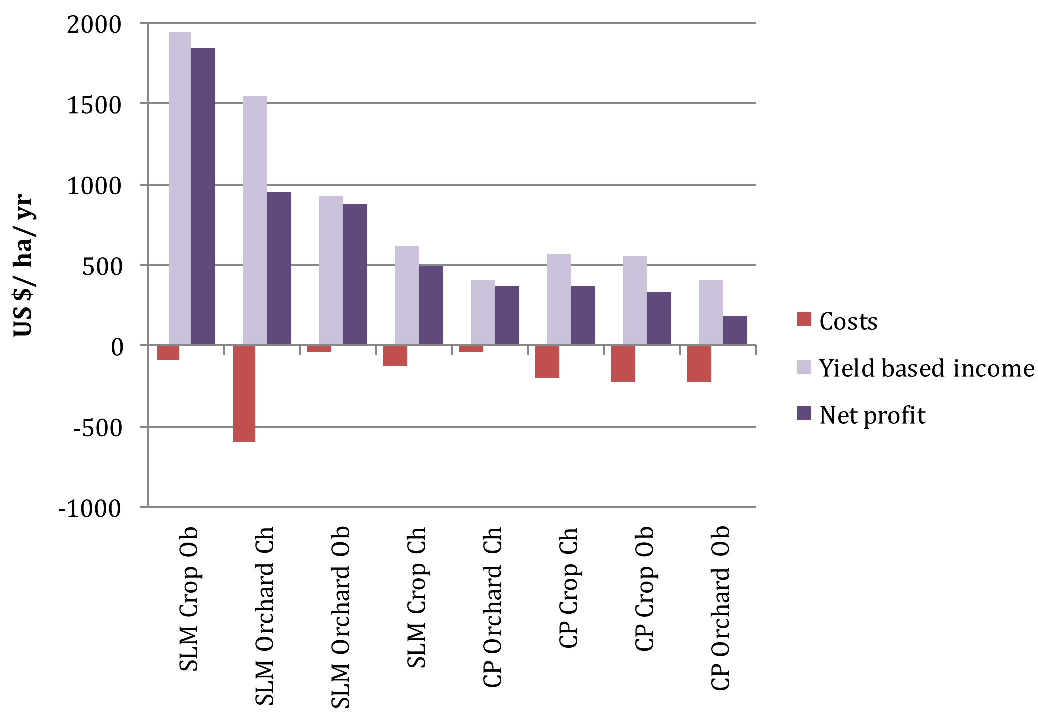

Figure 18: Compilation of annual costs and annual yield on a long-term perspective of ten years, with the resulting net profit per year. Sorted by descending net profits by study plots. Costs (represented by minus sign) include establishment costs and maintenance costs excluding labour and subsidies are subtracted if received. With Ob= Obishur and Ch= Chukurak watersheds.

In a long-term perspective, annual costs range from 40 to 600 US$ per ha (SLM orchard Obishur and SLM orchard Chukurak respectively), whereas yield ranges from 400 to nearly 2000 US$ per ha (CP orchard Chukurak and SLM cropland Obishur respectively). Highest net profit are shown by the SLM cropland Obishur, with a maximal net profit of 1850 US$ per ha, followed by the SLM orchard Chukurak. The latter has the highest costs, but also a high yield resulting in a net profit of nearly 1000 US$ per ha. The CP orchard Obishur has the lowest net profit with 200 US$. Average long-term net profit of SLM technologies is three fold higher than net profit gained by CP (1050 US$ to 310 US$ respectively). Crops have a 20 % higher net profit than orchards on average, which is mainly due to the maximum net profit gained by the SLM Crop Obishur.

The figure shows that profitability is strongly related to land use practice on a long-term basis. All the SLM technologies range in the upper half of the spectrum with highest net profit, whereas all CP are in the lower half. No clear pattern is observed in the distribution of orchards and croplands.

6.2.3 Soil organic carbon

The soil samples originating from the study plots were analyzed for SOC. The averaged SOC values at different depths are shown in Table 10.

Table 10: Average values of SOC [%] in a depth of 0-5cm (SOC 0-5), 5-30cm (SOC5-30), 30-50cm (SOC30-50) and 0-50cm (SOC0-50) for each study plot. With Ob= Obishur and Ch= Chukurak watersheds.

[%]	SOC 0-5	SOC 5-30	SOC 30-50	SOC 0-50
CP Pasture Ob	2.61	1.19	0.65	**1.11**
CP Pasture Ch	2.73	0.78	0.37	**0.81**
SLM Pasture Ob	1.63	1.06	0.57	**0.92**
SLM Pasture Ch	3.77	2.65	-	**2.84**
CP Orchard Ob	1.65	1.34	0.93	**1.21**
CP Orchard Ch	1.40	1.00	0.88	**0.99**
SLM Orchard Ob	1.33	1.00	0.89	**0.98**
SLM Orchard Ch	1.21	0.98	0.62	**0.86**
CP Cropland Ob	1.31	0.84	0.96	**0.94**
CP Cropland Ch	1.06	0.88	0.98	**0.93**
SLM Cropland Ob	1.84	1.83	1.55	**1.72**
SLM Cropland Ch	2.53	1.64	1.04	**1.49**

Average SOC up to 50cm depth (SOC 0-50) is 1.09 %, which is similar to SOC values with a similar regional character (Bettina Wolfgramm, 2007). Minimal average of SOC are shown the CP pasture Chukurak, the maximal SOC content is found in the SLM pasture Chukurak, followed by the SLM cropland in Obishur. Because the SOC 30-50 value for the SLM pasture in Chukurak is missing, the latter statement may be biased, although SOC content in the upper layer of the pasture is comparatively high. Figure 19 visualizes the variability of SOC content according to land use type and land use practice.

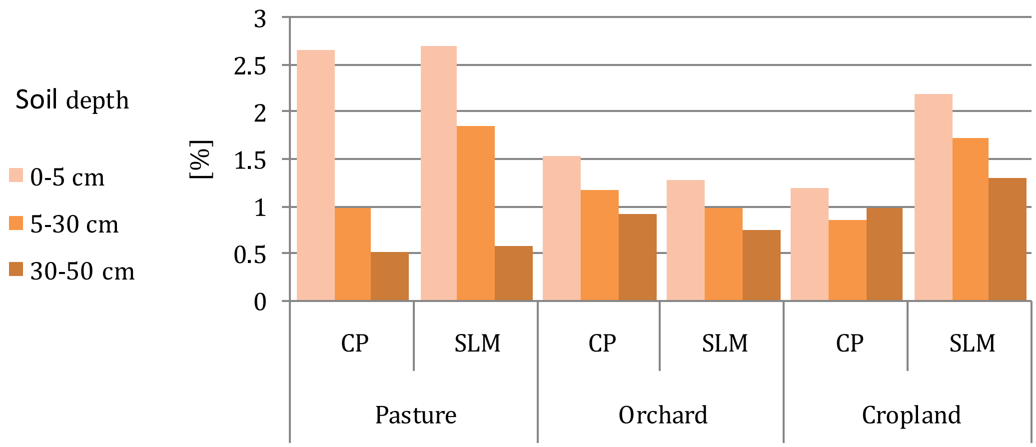

Figure 19: SOC in the soil depths 0-5cm, 5-30cm and 30-50cm averaged between the Obishur and Chukurak watershed.

Pastures have the highest organic content in the top layer (0-5 cm) and the lowest SOC content in the depth of 30 to 50 cm (30-50 cm). The decrease of SOC with depth is most pronounced for pastures. When looking at the comparative studies, SLM pastures show a more moderate SOC decrease with depth than CP pastures.

Orchards show a rather low SOC content, with average values around 1 % according to the management type. In all depths CP orchards have a slightly higher organic content than the comparative SLM technology.

Croplands show the greatest difference in SOC between SLM and CP. Between the comparative studies, the organic content is higher in the SLM cropland in all depths than in the CP cropland.

Discussion and explanation of differences in SOC levels between distinct land use types and land use practices types have to be considered with precaution. The past land use has influences on the present SOC content. The discussion is based on observations made on the field, as the history of the study plots is not known.

The similar SOC content among pastures may be due to the comparable ecological state of the pastures. In addition, it is probable that SLM pastures were common pasture in the past, showing presently a similar SOC. The high content can be explained by the presence of some flanks which are steep and hardly accessible for livestock. Samples from these flanks with abundant vegetation may have increased the SOC content (Wolfgramm, 2007).

The higher SOC content in CP orchards than in SLM Orchard is difficult to explain without knowing the past agricultural use. The difference, although small, is surprising as orchards have a greater vegetation cover than wheat crop according to observations. External input, like fertilizers may explain the higher SOC content of CP orchards.

CP croplands are small grain plots in contrast to perennial SLM croplands. The high and year-round vegetation cover of SLM croplands favours the organic content in soils.

In Figure 20, boxplots of all samples according to depth are illustrated.

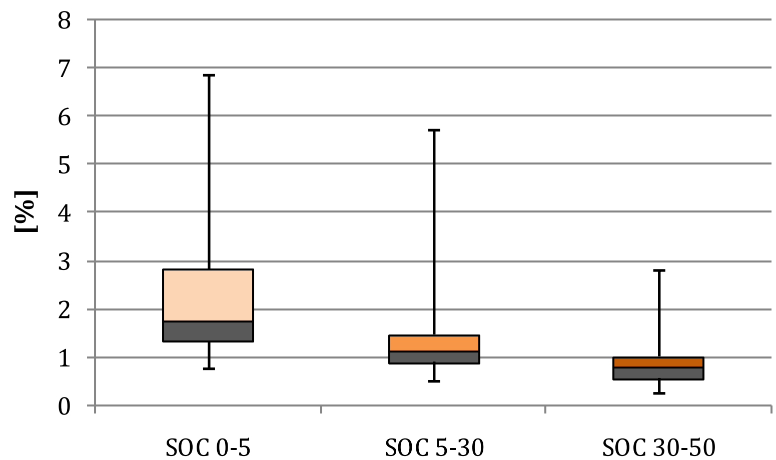

Figure 20: Boxplot showing SOC content per soil depth of 0-5cm (SOC 0-5), 5-30cm (SOC 5-30) and 30-50cm (SOC 30-50) of the study plots.

The top layer (SOC 0-5) shows the highest values with an average of 1.75%, decreasing in the SOC 5-30 and SOC 30-50 layer with an average of 1.14% and 0.86% respectively. The boxplots show that the percentage and variability of SOC decreases with depth.

6.2.4 Runoff

Runoff estimation is based on the following assumptions, which have to be taken into account when interpreting runoff results: All runoff (reduction) calculations are approximate by the CN of USDA SCS for each study plot (chapter 5.4.2). Runoff is calculated for a strong rainfall event in Muminabad, assuming that precipitation is 85 mm.

Table 11 shows runoff calculated with CN without considering slope (Q with CNII) and with slope (Q with CNIIα). As pastures have multiple flanks and slopes, an average slope was estimated. CNIIα was used for further calculations.

Table 11: Curve number CN, curve number slope CNII α and with the corresponding runoff Q [mm] of every study plot. With Ob= Obishur and Ch= Chukurak watersheds.

Study plot	CN	CNII α	Q [mm] with CN	Q [mm] with CNIIα
CP Pasture Ob	80.75	84.39	39.81	46.62
CP Pasture Ch	80.75	83.03	39.81	44.00
SLM Pasture Ob	79	82.67	36.77	43.32
SLM Pasture Ch	69	73.84	21.93	28.60
CP Orchard Ob	72.5	75.13	26.66	30.54
CP Orchard Ch	70.5	73.50	23.90	28.10
SLM Orchard Ob	63.5	64.83	15.43	16.90
SLM Orchard Ch	64	65.33	15.97	17.47
CP Cropland Ob	76	78.45	31.88	35.84
CP Cropland Ch	74	76.90	28.83	33.30
SLM Cropland Ob	69	72.75	21.93	27.01
SLM Cropland Ch	70.5	74.93	23.90	30.23

Runoff with slope shows higher values for all study plots than runoff without slope. The integration of the slope influences the runoff calculations. For few study plots the difference in runoff with CN and runoff with CNIIα is small. SLM orchards show the slightest increase due to a small inclination of the plot. The SLM Orchard Chukurak shows a small inclination due to the terracing of the plot, otherwise slope and CNIIα would be consequently bigger. Other plots, CP and SLM pastures and some croplands, have important differences in runoff. Pastures have heterogeneous and important slopes, increasing CNIIα. Croplands are cultivated on relatively steep slopes which are commonly observed in Muminabad. The SLM cropland Chukurak lies exceptionally in the upper part of the watershed which explains the big inclination and the difference between CN and CNIIα. Runoff may increase by 25 % when slope is taken into account in the CN calculation (SLM croplands).

In the next step CNIIα was used to calculate runoff for each plot with the equations in chapter 5.4.2. Figure 21 shows the calculated runoff, separated by land use type and management for the Obishur and Chukurak watersheds.

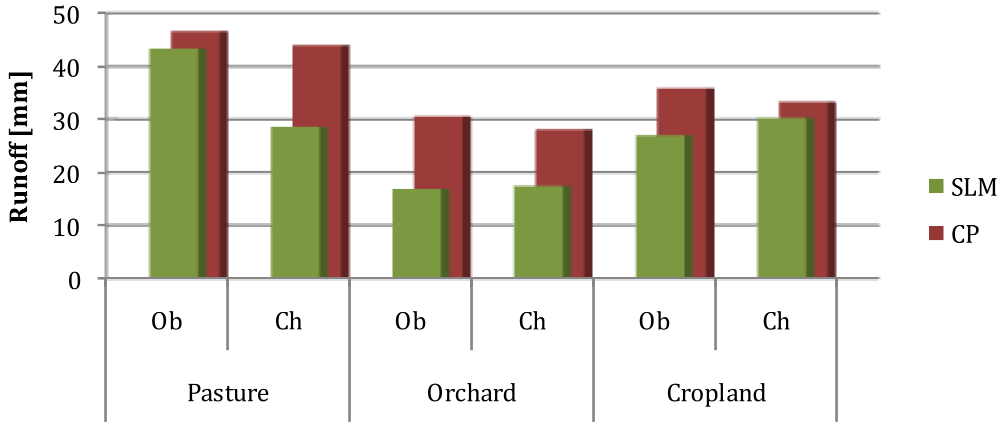

Figure 21: Runoff for CPs and the corresponding SLM technology, separated by land use type and watershed. Runoff is calculated based on CNIIα figures. With Ob= Obishur and Ch= Chukurak watersheds.

Runoff ranges from 16.90 mm (SLM orchard Obishur) up to a maximum runoff of 46.6 mm (CP in Obishur), with an average of 31.83 mm. SLM technologies generate 25% less runoff on average than CP. The lowest runoff is generated by the SLM orchards whereas pastures show the highest runoff rates in exception of the SLM pasture Chukurak. All SLM technologies show lower runoff rates than the comparative CP, although difference varies greatly.

The highest difference in runoff, between a comparative study is shown by the pastures in Chukurak and the orchards in Obishur. Maximum potential runoff reduction is 15.4 mm and 13.6 mm, reducing runoff by 35 % and 44 % for the pastures of Chukurak and the orchards of Obishur respectively. A small potential for runoff reduction is observed for the cropland in the Chukurak watershed and the pasture in Obishur (with 9 % and 7 % less runoff).

According to the runoff calculation, the implementation of SLM pastures and SLM orchards is the most effective for runoff reduction. As CP orchards already generate little runoff and establishment is costly, the focus for runoff reduction should be on pastures and croplands.

However, the runoff calculation by the CN model bears criticism. Huang et al. (2006) observes a discrepancy between the calculated and the measured data. Furthermore, CN values tend to underestimate the observed runoff. Fennessey et al. (2001) claim that the CN model over- and underestimates runoff by more than 30 %. According to the study the accuracy of CN decreases with the extent of the study area. CN calculation for watersheds smaller than 20 acres (~8 ha) is not recommended. In the present study, calculations are plot based. In exception of pastures, the studied plots have a smaller extent than the required minimal area defined by Fennessey et al. (2001).

As no runoff data exists for the district of Muminabad, no validation is possible for the modeled outcomes. The assessment of CN is based on several steps of classification through specified parameters. Whereas some parameters could be objectively classified (cover type and cover treatment) others, especially HSG were based on individual estimation. The subjective classification is though source of variance of CNs. For this purpose a range from worst and best CN values were created, and averaged for each studied plot. The difference between worst and best CN of a plot could be identical or relatively small, of 1 to 2 CN (orchards). In contrast, other land use practices (CP pastures, croplands) showed differences from 3 to 4 CN influencing further runoff calculations and scenario building.

Comparison with other studies is difficult as CN parameters are hard to compare for two study sites. Additionally, in studies using the CN model runoff is assessed at watershed level and not at plot level. Nonetheless, an attempt to compare the results obtained for Muminabad with data from publications for watersheds from the loess plateau in China (Gao et al., 2012Huang et al., 2006) is listed below. A comparison was made between selected study plots in Muminabad and the study plots in China where CN parameters seemed to be comparable (Table 12). The own results show the CN range from a worst case CN to a best case CN used to calculate average CN in the subchapter Runoff by Curve Numbers (chapter 5.4.2).

Table 12: Comparison of the CN with the range of minimum and maximum CN calculated for each study plot of selected land use types with other literature.

	Source	**CN**	**Known CN Parameters**
Pastures	Own results	81.5-85.8 (CP)	12-40 % (Slope)
		73.8-82.7 (SLM)	12-40 % (Slope)
	Huang et al. (2006)	71	17 % (Slope)
		78.6	47 % (Slope)
Perennial crops	Own results	72.8	15 % (Slope)
		76.3	23 % (Slope)
	Huang et al. (2006)	72.1	14 % (Slope)
		78.5	18 % (Slope)
Orchard	Own results	73.3-75.4 (CP)	12 % (Slope), poor (HSG)
		64.8-65.3 (SLM)	12 % (Slope), fair (HSG)
	Gao et al. (2012)	73	19% (Slope), poor (HSG)
		58	19% (Slope), fair (HSG)

The comparison shows that the outcomes between this study and other literature may vary, especially between different land use practices. Difference can be also explained by external factors from other studies as the quality of management (HSG), type of soil, steepness and others which remained unknown.

CN of pastures is similar, as the values from the literature (71 for 17 % and 78.6 for 47% of slope) correspond to the CN values of SLM pastures. In contrast, CP pastures have higher CN values than the literature. The land use practices expressed in HSG in Huang et al. (2006) are not known which is why comparison remains unsure. Perennial crops show similar values between the own results and literature. Perennial crops representing SLM croplands allow a meaningful comparison having the same land use practice. The only comparative difference between the perennial crops is the maximum CN by Huang et al. (2006) which shows a higher CN (78.5) although the slope is smaller (18 %). The CP orchards have very similar CN to orchards classified of poor HSG by Gao et al. (2012), although for the latter slope is being bigger. When comparing SLM orchards with the orchards in the study of Gao et al. (2012) with HSG classified as fair, difference is much more important (64.8-65.3 and 58 respectively).

CN numbers by the own assessment are comparable to the ones from literature within a certain range (from maximum to minimum CN per studied plot) and when considering exceptions. Difference within the same land use type might be still important when the land use practice or HSG respectively are not known. This reflects the big influence of land use practices having on CN and consequently runoff. The allocation of CN has to be made with precision as a slight increase of CN can bias runoff greatly, according to a personal consultation with Caritas Switzerland.

6.2.5 Benefits according to the WOCAT classification

Quoting the impact of benefits and disadvantages of each SLM technology and CP revealed the following ranking from best to worst study plot (Figure 22):

Ranking		Sum of benefits and disadvantages
SLM orchard Ob		15.3
SLM cropland Ch		14
SLM orchard Ch		12.7
SLM cropland Ob		11
SLM pasture Ob		8.7
SLM pasture Ch		7.3
CP orchard Ch		-7
CP cropland Ch	CP orchard Ob	-8.3
CP cropland Ob		-9.7
CP pasture Ch	CP pasture Ob	-12.3

Figure 22: Descending list from best to worst practice according to summed benefits and disadvantages concerning productivity, soil quality and runoff reduction,from the WOCAT QT. With Ob= Obishur and Ch= Chukurak watersheds.

Highest rank is shown as the SLM orchard Obishur with 15.3 points; bith Cp pastures had the lowest rank with -12.3 points. SLM technologies have all positive values, thus bear more benefits than advantages. CPs have all negative values, as more disadvantages than benefits were observed. In both types of land use practices - SLM technologies and CP pastures have the lowest values. Pasture is the least beneficial land use type within a land use practice.

The results of the ranking confirm the selection of study plots that were attributed to SLM technologies and CPs. Furthermore, the assessment was influenced by subjectivity as some prejudice could not be avoided by myself in the field. Thus, a special focus was paid on benefits when being on a SLM plot, vice versa more attention was paid to degradation signs on common plots. This observation may explain the big gap between the lowest ranked SLM technology (SLM pasture Chukurak) and the highest ranked CP (CP orchard Chukurak).

Furthermore, the ranking does not show if a practice has few benefits or disadvantages with a high impact, or many benefits or disadvantages with low impact.

6.2.6 Soil quality by visual field assessment

Figure 23 shows the ranking of the visual field assessment:

Ranking		Average of categories
SLM cropland Ob		1.03
SLM pasture Ch		1.58
SLM cropland Ch		1.77
SLM orchard Ob		2.31
SLM orchard Ch		2.42
CP cropland Ob		2.56
CP orchard Ob		2.61
SLM pasture Ob	CP orchard Ch	2.63
CP cropland Ch		2.71
CP pasture Ch		2.9
CP pasture Ob		3

	Soil quality
(green)	Good (1 –1.67)
(yellow)	Fair (1.67 – 2.33)
(red)	Low (2.33 – 3)

Figure 23: Ranking and categorization of the study plots with the visual field assessment. With Ob= Obishur and Ch= Chukurak watersheds.

The SLM cropland Obishur and SLM pasture Chukurak are ranked the highest, representing a good soil quality. The SLM cropland Chukurak and SLM orchard Obishur are classed as fair soil quality. The rest of the practices show a low soil quality according to the ranking. Both common pastures are at the end of the ranking.

Most of the SLM technologies are of good and fair quality, in exception of the SLM orchard Chukurak and the SLM pasture Obishur. Pastures are ranked of lower quality than orchards and croplands of the same land use practice. This observation was also made by the assessment of WOCAT benefits. Thus, the SLM pasture Chukurak is exceptional showing good soil properties.

6.2.7 Synthesis of the benefits and triangulation

The quantitative results of productivity, soil quality and runoff reduction were classified into three categories to enable a direct comparison between the benefits. For soil quality and runoff, interval scaling was used to range the SOC and runoff data into classes of low, fair and high benefit. For productivity a random scaling had to be considered, as two study plots showed outliers with a very high yield. In order to represent the benefits together in a spiderweb, the classes of low, fair and high benefit were listed with number 1, 2 and 3 respectively. The Figure **24**.a and 24.b show benefits separated by SLM technologies and CPs by spiderwebs.

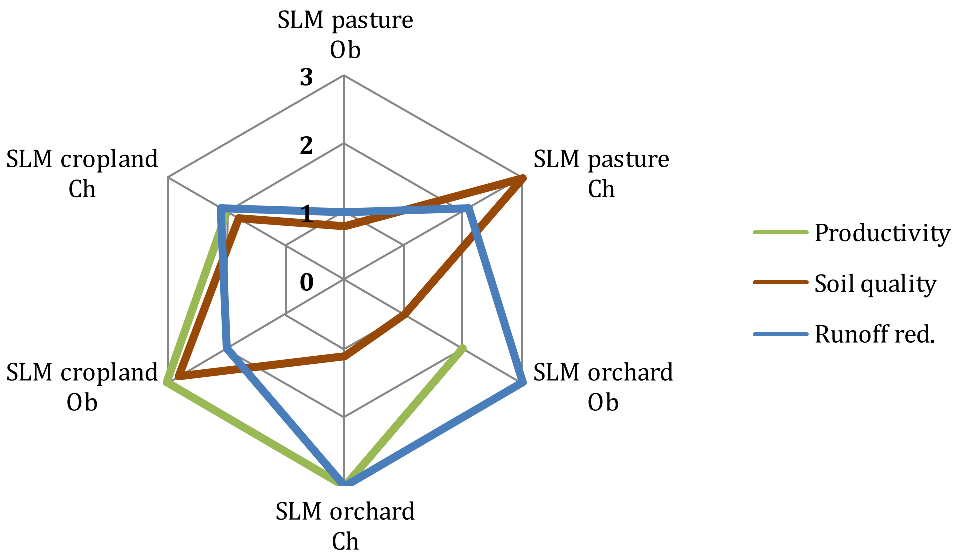

Figure 24.a: Spiderweb of the SLM technologies with the benefits: productivity, soil quality and runoff reduction. Range is from 1 to 3 for low to high benefit respectively. With Ob= Obishur and Ch= Chukurak watersheds. (Note: No yield for pastures, rank 0 is for better readability)

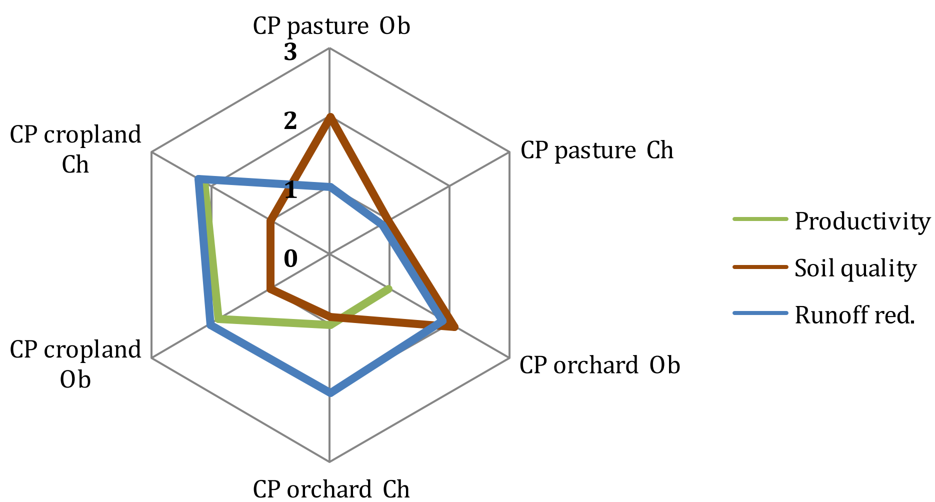

Figure 24.b: Spiderweb of the CPs with the benefits: productivity, soil quality and runoff reduction. Range is from 1 to 3 for low to high benefit respectively. With Ob= Obishur and Ch= Chukurak watersheds. (Note: No yield for pastures, rank 0 is for better readability)

According to Figure 24.a, the impact of the benefit indicators is highly dependent on the land use type. Yield, SOC and runoff, being indicators for productivity, soil quality and runoff reduction show low, fair and high benefits among the SLM technologies.

The SLM cropland Obishur is the study plot with the highest benefits having high benefit in productivity and soil quality and fair benefit in runoff reduction. Lowest benefits shows the SLM pasture Obishur with low soil quality and low runoff reduction.

Different observations could be made when comparing between the same land use types. The SLM pastures differ greatly from each other, as the SLM pasture Obishur shows low soil quality and low capacity for runoff reduction. The SLM pasture Chukurak in contrast, is more beneficial through high soil quality and a fair runoff reduction potential. Benefits of both SLM orchards are very similar, showing only a difference in productivity. Productivity of the SLM orchard Chukurak is higher whereas soil quality is ranked low and runoff reduction capacity high for both orchards. The comparison between the SLM croplands shows evidently that the SLM cropland Obishur is more beneficial, having high benefits in productivity and soil quality and a fair potential for runoff reduction. The SLM cropland Chukurak shows a fair benefits for productivity, soil quality and runoff reduction.

In Figure 24.b the CPs show low and fair impacts for all benefit indicators. No high impact is recorded. The CP croplands and the CP orchard Obishur are the most beneficial study plots with two fair and a low benefit impacts. The CP pasture in Chukurak shows low benefits.

The comparison between the same land use types shows that CP pastures are similar, having generally low benefits. The CP pasture Obishur records a fair benefit in soil quality compared to the CP pasture Chukurak with a low soil quality. Both pastures have low runoff reduction capacities. Both CP orchards show fair benefits in runoff reduction. The CP orchard Obishur has the more a fair soil quality and low productivity. The CP orchard Chukurak records low benefits in productivity and soil quality, which is why the latter studied plot is less beneficial than the CP orchard Obishur. The benefits of the CP orchards are all ranked the same. Productivity and runoff reduction is ranked of fair benefit and soil quality of low benefit.

When comparing between the paired study plots The SLM pasture as well as the CP pasture in Obishur have rather low benefits. Runoff reduction is low for both orchards, the CP pasture show a fair soil quality in contrast to the low soil quality in the SLM pasture. The SLM Pasture Chukurak has higher benefits by far compared to the CP pasture with only low benefits. The comparison between the orchards in Obishur shows that the SLM orchard has higher benefits of productivity and runoff reduction but lower soil quality than the corresponding CP orchard. The SLM orchard Chukurak records much higher benefits in productivity and runoff reduction than the Cp orchard. Soil quality is low for both. The SLM orchard Obishur is more beneficial than the CP orchard with higher benefits in productivity and soil quality. Runoff reduction is ranked as fair for both croplands. The croplands in Chukurak have comparable benefits, mostly of fair impact. Only soil quality is ranked low in the CP orchard Chukurak.

Overall it can be observed that SLM technologies show generally higher benefits than CPs. Soil quality is the only benefit with few exceptions where benefit is ranked higher in CPs than in SLM technologies.

The on-site benefit soil quality was assessed by quantitative and qualitative methods – soil organic carbon, benefit assessment by WOCAT QT and the visual field assessment. By means of a spiderweb the three different approaches for soil quality were triangulated (Figure 25).

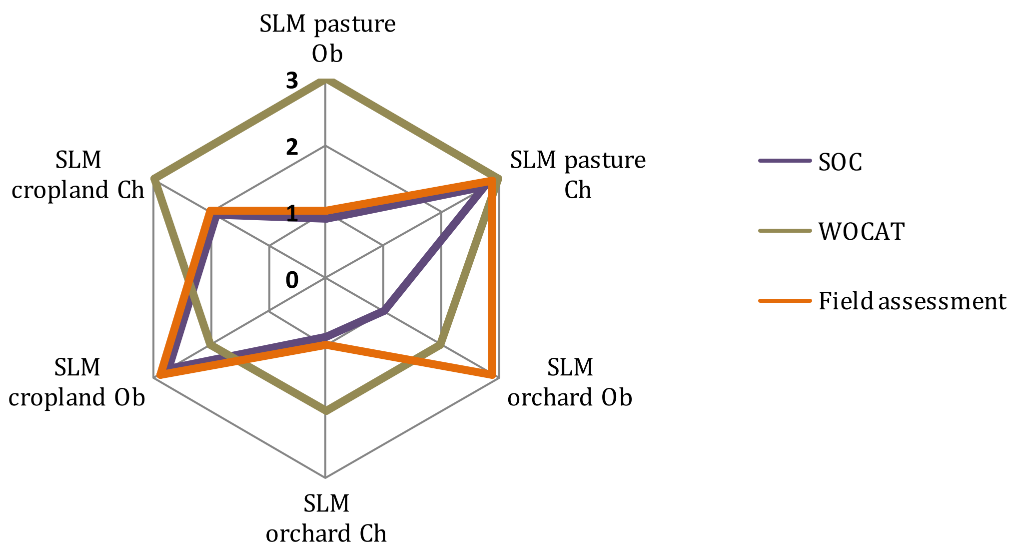

Figure 25: Triangulation of soil quality by the three different methods for the SLM technologies. Range is from 1 to 3 for low to high benefit respectively. (Note: No yield for pastures, rank 0 is for better readability). With Ob= Obishur and Ch= Chukurak watersheds.

The spiderweb illustrates that the trajectory between the SOC curve and the curve of the visual field assessment is very similar except of the SLM orchard in Obishur. The curve by WOCAT shows a different trajectory through almost all SLM technologies.

The types of approach can explain this observation. The soil organic carbon is a quantitative assessment. The visual field assessment is based on observations and measurements, which might be influences by some subjectivity when estimating soil and surface erosion visually. In contrast, the qualitative assessment by WOCAT is based on visual judgment, and is thus more sensitive to subjectivity. Although the trajectory of WOCAT benefit is different to the others, it allows representing benefits in the context of the surrounding environment. In other words, benefits observed in the field in Muminabad, might not be classed as benefit in another context with better soil conditions.

6.3 Runoff reduction scenarios

In order to successfully build scenarios the area of each land use type per middle zone of a watershed had to be determined. Strahm (2011) made land use classifications in the watersheds, but used different land use classes, which made a clear division into pastures, orchards and croplands impossible. The area for each land use type was defined based on Caritas reports and the hydrologic analysis by Vlieghe (2012) (Table 13).

For orchards only the total area per watershed was known. According to personal field observations, orchards are located mainly in the middle zone. Consequently, the total area of orchards was considered for the scenarios.

Scenario classes are built, as the real distribution of CP and SLM technologies of a land use type could not be identified. Following scenario classes were developped:

- Scenario 0: 100% CP, 0% SLM technologies
- Scenario 25: 75% CP, 25% SLM technologies
- Scenario 50: 50% CP, 50% SLM technologies
- Scenario 75: 25% CP, 75% SLM technologies
- Scenario 100: 0% CP, 100% SLM technologies

The scenarios range from the worst case (Scenario 0) with the whole area using CP, to the best case (Scenario100) where SLM technologies are implemented on all plots. Graded scenarios, with a minor area of SLM technologies (Scenario 25), with a balanced division (Scenario 50) and with predominantly SLM technologies (Scenario75) were created in between. As stated in chapter 5.5 the creation of runoff scenarios is based on extrapolated values from the study plots. The whole defined area is extrapolated with the runoff originating from the runoff calculation of a study plot.

Table 13 shows the results of runoff volumes and runoff reduction volumes per scenario and land use type. Runoff volumes are shown in the first row per watershed and the second row shows the runoff reduction volume. The runoff reduction volume shows the difference between the runoff volume of Scenario 0 and Scenario X. The difference represents the potential runoff reduction when SLM technologies are applied instead of CP. Scenario 0, being simultaneously the worst case scenario, represents the status quo of maximum runoff volume from which the potential runoff reduction volume is determined.

			Total area (middle zone) [ha]	Scenario 0	Scenario 25	Scenario 50	Scenario 75	Scenario 100	Contribution to runoff reduction [%]
Obishur	**Runoff** [m³ *10³]	*Pasture*	*1600*	*746.0*	*732.8*	*719.6*	*706.4*	*693.2*	-
		Orchard	*400*	*143.4*	*134.5*	*125.7*	*116.9*	*108.1*	-
		Cropland	*1300*	*397.0*	*352.7*	*308.4*	*264.0*	*219.7*	-
		Total	**3300**	**1286.3**	**1220.0**	**1153.6**	**1087.3**	**1021.0**	-
	Runoff reduction [m³ *10³]	*Pasture*	*1600*	*0*	*13.2*	*26.4*	*39.6*	*52.8*	*19.9*
		Orchard	*400*	*0*	*8.8*	*17.6*	*26.5*	*35.3*	*13.3*
		Cropland	*1300*	*0*	*44.3*	*88.7*	*133.0*	*177.3*	*66.8*
		Total	**3300**	**0**	**66.3**	**132.7**	**199.0**	**265.4**	**100**
		Total [%]		**0**	**5**	**10**	**15**	**21**	
Chukurak	**Runoff** [m³ *10³]	*Pasture*	*1000*	*440.0*	*401.5*	*363.0*	*324.5*	*286.0*	-
		Orchard	*300*	*84.3*	*76.3*	*68.4*	*60.4*	*52.4*	-
		Cropland	*500*	*166.5*	*162.7*	*158.8*	*155.0*	*151.2*	
		Total	**1800**	**690.8**	**640.5**	**590.2**	**539.9**	**489.6**	
	Runoff reduction [m³ *10³]	*Pasture*	*1000*	*0*	*38.5*	*77.0*	*115.5*	*154.0*	*76.5*
		Orchard	*300*	*0*	*8.0*	*15.9*	*23.9*	*31.9*	*15.9*
		Cropland	*500*	*0*	*3.8*	*7.7*	*11.5*	*15.3*	*7.6*
		Total	**1800**	**0**	**50.3**	**100.6**	**150.9**	**201.2**	**100**
		Total [%]		**0**	**7**	**15**	**22**	**29**	

Table 13: Runoff and runoff reduction per land use type and per watershed. Scenario 0 is considered to be the worst case scenario with maximum runoff and no implemented SLM technologies and Scenario 100 is considered to be the best case scenario with minimal runoff after total implementation of SLM technologies in pastures, orchards and croplands.

The maximum runoff reduction volume is estimated to be 265’000 m^3 and 201’000 m^3 for Obishur and Chukurak watersheds, representing a runoff reduction of 21 % and 29 % compared to scenario 0.

The runoff reduction volume is not significantly higher in Obishur than in Chukurak, although the area in Obishur is twice as big as in Chukurak. Reasons and differences may be found when focusing the discussion on the watersheds.

Obishur

Croplands show the highest potential for runoff reduction, followed by pastures and then orchards when the total area for each land use type is considered. Runoff reduction potential calculated per hectare reveals that croplands, followed by orchards and then pastures show the highest potential.

Pastures occupy 1600 ha of the middle zone in Obishur. If this area is to become totally degraded, by classification into Scenario 0, nearly 750’000 m^3 of runoff is generated. A total improvement through SLM technologies of the pasture area would save over 50’000 m^3, which represents nearly 20 % of the total runoff reduction (Scenario 100).

The reason for the relatively small reduction is the depleted state of the SLM pasture. The runoff difference between the SLM pasture and CP pasture is low. Consequently the runoff reduction potential by implementing a SLM technology remains low. Due to the large extent of area runoff generation is important, but the SLM pasture shows a high potential for further improvement.

Orchards, occupying a much smaller area in the middle zone, can reduce the maximum total runoff by 13 % as shown in the best case scenario (Scenario 100). They generate 35’000 m^3 less runoff than in the worst case scenario (Scenario 0).

Croplands are widespread, covering an area of 1300 ha in the middle zone. A maximum runoff reduction of nearly 180’000 m^3 is projected, representing two thirds of the maximum runoff reduction volume of the watershed. Croplands have the biggest impact on runoff volume reduction. In case of an improvement by half of the croplands (Scenario 50), runoff volumes can be reduced by one third which would be nearly 90’000 m^3.

The outcomes for the Obishur from Table 13 are illustrated in Figure 26. It underlines the conclusion, that croplands bear the highest potential for runoff reduction by SLM improvement. Pastures together with orchards reduce runoff volume maximally by one third.

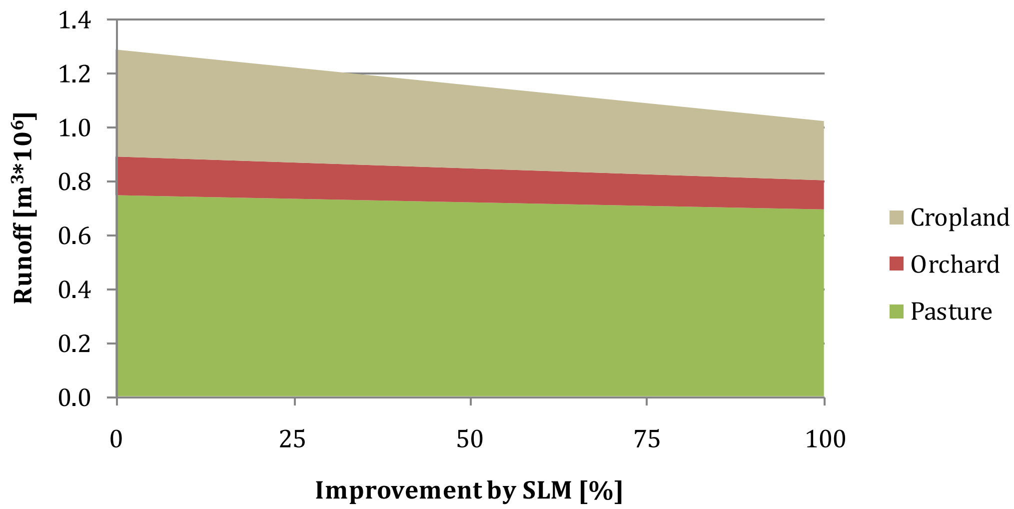

Figure 26: Scenarios for runoff reduction in the watershed of Obishur.

Chukurak

Runoff volume from the middle zone of the Chukurak watershed can be reduced by 29% if the total area of pastures, orchards and cropland is improved by SLM technologies (Scenario 100). Pastures contribute the most, followed by the orchards and then croplands when considering the total area in the calculations. When the runoff reduction potential is calculated per hectare croplands, followed by pastures and then orchards show the highest potential to reduce runoff.

Pastures contribute the most to runoff reduction. An improvement of 1000 ha of pastures, would reduce runoff by over 150’000 m^3, which is over 75 % of the total maximum runoff reduction.

A total improvement of orchards by SLM (Scenario 100) induces a total reduction of approximately 30’000 m^3, reducing 38 % runoff in comparison to Scenario 0. Improved orchards decrease the total runoff volume by nearly 16 % maximally.

Croplands show the least influence on runoff reduction by 15’000 m^3, representing 9 % of the total reduction volume. Croplands extend over a bigger area than orchards (500 ha and 300 ha respectively) but reduce runoff half as much as orchard for scenario 0.

Figure 27 visualizes the results from Table 13. It illustrates the following conclusion: pastures have the highest potential by far to reduce runoff volume, accounting for 75 % of the total reduction. Reduction by orchards, followed by crops is important but minor when comparing with pastures.

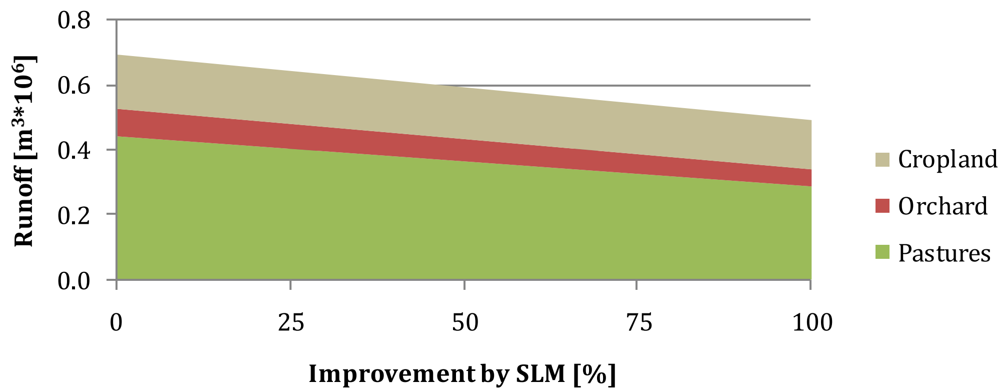

Figure 27: Scenarios for runoff reduction in watershed of Chukurak.

6.4 Methodological critique and outlook

The absence of (long-term) data in the study area in the Muminabad district demanded for alternative research concepts, whereas a comparative study analysis seemed to be adequate. Nonetheless, the paired case study bore some challenges which could not be fully overcome.

The study concerning DDR focuses on the spring season, as disaster are mostly observed in the months of April and May in Muminabad district. The field research conducted in the summer months required a lot on imagination to reconstruct the biophysical characteristics in spring. As I had no previous field experience in similar regions the reconstruction of the spring situation is based on hypotheses and could be never verified throughout the thesis. Especially, the qualitative assessments and the documentation by WOCAT are partly based on the impressions made in field in the summer months, which may vary to the conditions in spring.

The Obishur and Chukurak watersheds are geographically very close. Their biophysical and human similarities allow conducting comparative studies. However, differences could be observed on plot scale. External factors between paired plots were respected as far as possible in the study. Because some plots with a specific land use type or management were difficult to find in the middle zone, plots with a distinct location were considered for the analysis. This hindered the comparability of the external plot factors. Furthermore the distinction between SLM technology and CP was not always obvious, especially for pastures, as all pasture show an advanced stage of overgrazing. Additionally, the big extent and the heterogeneity of pastures did not facilitate a uniform documentation and comparison.

Collected data on the field represent snap-shots. For the SOC analysis information about the previous use of the plots would be important in order to discuss the measured results. Long-term data would also be interesting for the yield assessment, where trends need to be studies for detecting meaningful outcomes.

Weaknesses in runoff modeling are described in more detail in chapter 6.2.4. The CN method tends to over- or underestimate values, depending on plot size and cultivation practices. Unfortunately, no runoff data exist to compare and calibrate the modeled data.

Furthermore, data originating from the WOCAT QT showed unverifiable information in some cases, which calls the quality of data into question. Field experience showed that some questions posed to the farmers were difficult for them to understand and consequently difficult to answer. Questions relating to past activities, especially in the establishment phase of plots, showed uncertainties in the answers due to the long time-span since establishment. Benefits assessed by QT tend to be overestimated, because a special focus was placed in the identification of benefits.

The visual field assessment was created based on existing methods for the visual documentation of the plots. These visual assessments were tailored for climatic zones and conducted in Great Britain and Switzerland. The transfer of the visual indicators from the original environment into the context of Tajikistan needs a more adequate adaptation. Additionally, indicators for the visual field assessment were selected according to the feasibility and the availability of time. A broader range of indicators would be recommended for further assessments to raise representativeness.

The synthesis by spiderwebs integrates the qualitative with the quantitative outcomes in this study through interval scaling of the results. The idea was to compare the benefits against each other, between the land use types and comparative studies. Although spiderwebs provided the desired comparison, it remained as a rough estimation. A more elaborated synthesis with a more detailed scaling method would allow a deeper analysis by means of spiderwebs.

Considering the critique, following proposals can improve future studies:

- Methodological preparation:
  A more detailed preparation of the methods considered to be applied and a more specified definition of the goals to achieve in the study would have helped to use the research in field more target-oriented and effective.
- Long-term studies with regular data collection:
  To see trends and development and to maintain important contacts and sources of information. The more long-term studies would reflect seasonal variability which is substantial when research is focusing on specific seasons.
- Raise representativeness and validity of data:
  For indicators where a better funding of results would be desirable (e.g. for runoff reduction and soil productivity) additional watersheds could be considered for the assessment in order to get more representative average values.
- Knowing the past to understand present and future processes and conditions:
  Important for SOC data, but also for interviews, to have a broader background and knowledge on order to detect trends and patterns.

- Establishment of test plots:
  Costly and time consuming measure, however this would have significant advantages for paired study approaches, due to the elimination or limitation of external factors which bias the study.

7 CONCLUSION

This study provides an assessment and analysis of on-and off-site benefits and related costs of implemented SLM technologies in the watersheds of Obishur and Chukurak in Muminabad district, Tajikistan. The on-site benefits were defined as productivity and soil quality, the off-site benefit was runoff reduction in terms of disaster risk reduction (DRR). For each benefit a specific indicator was determined; namely yield for productivity, the soil organic carbon (SOC) for soil quality and runoff by curve number (CN). A part from the quantitative assessment, a qualitative analysis of benefits by WOCAT and a visual field assessment was conducted. The analysis was carried out on six comparative studies of two land use practices, as SLM technologies and common practices (CP). The comparative studies focused on the main land use types, being pasture, orchard and cropland, in the middle zone of the two watersheds. Simultaneously, the study aimed to assess the establishment and the recurrent costs providing a cost-benefit analysis. The cost-benefit analysis was projected in a short-term of one year and in a long-term of ten years after establishment of the plots.

Results showed that SLM technologies are highly expensive in a short-term compared to CP, when both material and labour inputs are included. Even in a long-term, costs of SLM technologies were up to ten times higher than CP including material and labour costs. When excluding labour, costs are similar between SLM technologies and CP in a long-term.

The quantitative assessment of productivity revealed that croplands and orchards show the same yields in average. In contrast SLM technologies record higher yield by factor three compared to CP. Consequently, productivity depends primarily on the land use practice than on the land use type. Net profit was calculated by the difference of yield and costs, representing only material costs. In a short-term CP croplands were the only plots with a positive net profit. Orchards and SLM croplands have high establishment costs, without having yield the first years. In a long-term the average yield of SLM technologies was three time higher compared to CP with 1050 US$/ ha and 310 US$/ ha respectively. Average SOC content was 1.09 %. SOC content was higher in all depths for SLM pastures and SLM cropland compared to CP pastures and CP croplands. SLM Orchards showed a slightly lower SOC content in all depths than CP orchards. Past land use practices influence the present SOC content. Therefore knowing the past land use practices could explain the lower SOC content in SLM orchards. Regarding runoff reduction, the standard CN runoff method was extended by the factor slope as it has impact on runoff behaviour. Runoff increased with slope from 9 % to 25 % depending on the plot. Pastures and a few croplands had steep slopes, resulting in a high additional increase of the runoff volume. Orchards had generally a slight slope or were terraced which increased runoff to a much lesser extent. Total runoff was highest for pastures (28.6 mm - 46.6 mm), followed by croplands (27.0 mm – 35.8 mm) and then orchards (16.9 mm – 30.5 mm). SLM technologies generated 25 % less runoff than CPs in average. The difference between a SLM technology and a CP of the same comparative case study represents the potential runoff reduction volume. A potential runoff reduction of

7 % to 44 % was observed depending on the land use practice. In absolute numbers pastures in Chukurak and the orchards in Obishur showed the highest potential reduction volume by 15.4 mm and 13.6 mm respectively.

The qualitative benefit assessment by WOCAT ranked all SLM practices as being more beneficial than CPs. Within the same land use practice pastures are the least beneficial land use type regarding productivity, soil quality and runoff reduction. The visual soil assessment classified four of the six SLM technologies as having good and fair soil quality. Two SLM practices (SLM Orchard Chukurak; SLM pasture Obishur) and all CPs were ranked as having low soil quality.

Three impact classes (low, fair, high) for the on-and off-site benefits were built, to rank the studied plots by means of a spiderweb. This synthesis underlined that the impact of benefit varies according to land use practice and land use type. The synthesis by land use practice revealed that SLM technologies are more beneficial than CPs in general. CPs recorded only low and fair benefits for soil quality, productivity and runoff reduction. SLM technologies show mostly fair and high benefits. Within the SLM technologies orchards followed by croplands showed a high comparability of the benefit impacts. The SLM pastures contrasted greatly between each other. Within the CPs, both croplands had similar impacts of the benefits. The impact of the benefits differed much more between CP orchards and CP pastures. When synthesizing the comparative studies, the pastures in Chukurak, the orchards in Chukurak and the croplands in Obishur showed the most significant differences in the impact of benefits. This difference between comparative studies represents simultaneously the potential benefits to gain, when implementing SLM technologies.

The triangulation of the three applied methods for the soil quality assessment revealed that the quantitative method by SOC correspond mostly to the qualitative visual field assessment. The WOCAT benefit assessment showed the big discrepancies compared to the other two methods. The detected differences might call for adjustments in the methodological design. However, the assessment by WOCAT allows representing the benefit relatively to the environmental context. SOC and visual field assessment might provide results of a more absolute nature, independent from local conditions in Muminabad.

A further objective of the present study consisted of the building of runoff reduction scenarios in the middle zone of the two watersheds. The runoff reduction scenario represents the extrapolated runoff reduction potential at plot level to watershed level. Scenario classes corresponded to the improvement by SLM technologies in percentages of the area occupied by the three land use types. Worst case to best case scenarios of implemented SLM technologies were built to assess the potential runoff reduction volume generated in the middle zone.

In the Obishur watershed a maximum reduction of 265’000 m^3 (21 %) can be expected when SLM technologies are fully implemented on the three land use types in the middle zone. A potential maximum runoff reduction of 201’000 m^3 (29 %) can be correspondingly achieved in the Chukurak watershed. In Obishur watershed croplands contribute the most to the runoff reduction due to the big area they cover and the highest runoff reduction potential per hectare. Pastures show the highest potential for runoff reduction in Chukurak as they extend over the biggest area in the middle zone. Highest runoff reduction potential per hectare show also croplands, but they cover a much smaller area in Chukurak.

The provided results of this study show a promising potential for the implementation of SLM technologies in Muminabad. SLM technologies are costly on a short-term, however long-term costs do not differ from CPs. Generally, SLM technologies have higher productivity and generate lower runoff compared to CPs. Soil quality assessed by SOC showed a higher content and consequently better soil quality in SLM technologies, in exception of SLM orchards. However, higher soil quality for all SLM technologies was documented by the WOCAT questionnaire and by the visual field assessment. Moreover, the runoff reduction scenarios revealed that the implementation of SLM technologies can reduce runoff volumes by almost 30 %. These findings point out that land use practices play an important role in respect of DRR in Muminabad. The implementation of SLM croplands showed the highest potential for runoff reduction. However, pastures cover generally a bigger area than croplands in the watersheds. An implementation of SLM pastures could be consequently more beneficial in terms of runoff reduction, all depending on the land use distribution within a specific watershed.

The mixed method approach appeared to be enriching for the study as qualitative and quantitative methods complemented each other. The methodological combination and the multifaceted analysis of costs and benefits allowed generating a wide range of results. Thus, a more elaborated synthesis of the various results could lead to additional findings. Long-term studies with regular data collection are recommended to reaffirm the present results and observe changes in benefits.

The study underlines that not only individual stakeholders gain advantages by on-site benefits but the whole local community profits from the implementing of SLM technologies. However, the adoption rate of SLM technologies still remains low in the district. The high establishment costs of SLM technologies may discourage farmers to invest, especially when benefits do not manifest immediately. More focus should be spent on knowledge transfer, lessons learned and capacity building of the local community. Incentives or credits should be offered for innovative farmers to promote the implementation of SLM technologies and a sustainable development of Muminabad district.

REFERENCES

Ayed, M., and Mohammad, A. (2010). The impact of vegetative cover type on runoff and soil erosion under different land uses. *Catena*, 81(2), 97–103.

Breu, T., and Hurni, H. (2003). The Tajik Pamirs Challenges of Sustainable Development in an Isolated Mountain Regio. p. 80 pp. Centre for Development and Environment CDE, Bern.

Bühlmann, E. (2006). Assessing Soil Erosion and Conservation on the Loess Area of Faizabad - Western Tajikistan. Integrating WOCAT Methods with a GIS-based RUSLE Model. *Diploma Thesis.* Centre for Development and Environment CDE, Bern.

Casenave, A., and Valentin, C. (1992). A runoff capability classification system based on surface features criteria in semi-arid areas of West Africa. *Journal of hydrology*, 130, 231–249.

Catt, J. A. (2001). The agricultural importance of loess. *Earth-Science Reviews*, 54(1-3), 213–229.

Cerdan, O., Souchère, V., Lecomte, V., Couturier, A., and Le Bissonnais, Y. (2001). Incorporating soil surface crusting processes in an expert-based runoff model: Sealing and Transfer by Runoff and Erosion related to Agricultural Management. *Catena,* 46, 189–205.

Chabot, P., and Tondel, F. (2011). A regional view of wheat markets and food security in Central Asia - with a focus on Afghanistan and Tajikistan. United Stated Agency for International Development Famine Early Warning Systems Network FEWS NET, United States.

SDC (2013). Activities in Tajikistan. Swiss Agency for Development and Cooperation SDC, Bern. http://www.swiss-cooperation.admin.ch/centralasia/en/Home/Activities_in_Tajikistan. Access 12.12.2013.

Corvalan, C., Hales, S., and McMichael, A. (2005). Ecosystems and Human Well-Being. Health Synthesis. A report of the Millenium Ecosystem Assessment. World Health Organization WHO, Geneva.

Darghouth, S., Ward, C., Gambarelli, G., Styger, E., and Roux, J. (2008). Watershed Management Approaches , Policies , and Operations: Lessons for Scaling Up. Water Sector Board Discussion Paper Series, (11). The World Bank, Washington DC.

Doran, G. T. (1981). There’s a S.M.A.R.T. way to write management's goals and objectives. *Management Review*, 70(11), 35–36.

Eggenberger, S. (2011). Effects of Labour Migration on Rural Livelihoods in Tajikistan With a special regard on the interlinkages to agricultural land use. MSc Thesis. Centre for Development and Environment CDE, Bern.

EM-DAT. (2013). The OFDA/CRED International Disaster Database. http://www.emdat.be/result-country-profile, Access 12.12.2013.

Eswaran, H., Lal, R., and Reich, P. F. (2001). Land degradation: an overview. http://soils.usda.gov/use/worldsoils/papers/land-degradation-overview.html, Access: 12.12.2013

Euler, G., and Knauf, D. (1999). Ingenieurhydrologie und Wasserwirtschaft. In W. Schröter (Ed.), Grundlagen des Wasserbaus (4. Auflage). Werner Verlag, Düsseldorf.

FAO. (2006). The new generation of watershed management. FAO Forestry Paper, 150. Food and Agriculture Organization of the United Nations FAO, Rome.

FAO. (2008). FAO's Role in the 2008/2009 Humanitarian Food Security Appeal for Tajikistan. Food and Agriculture Organization of the United Nations FAO, Rome.

FAO, and Ministry of Agriculture. (2011). Crop and Food Security Assessment Mission Report Tajikistan 2011. Dushanbe, Tajikistan.

FAO, and CDE. (2011). Highlands and Drylands - Mountains, a source of resilince in arid zones (p. 113). Rome. Food and Agriculture Organization of the United Nations FAO and Centre for Development and Environment CDE, Rome.

Fennessey, L., Miller, A., and Hamlett, J. (2001). Accuracy and precision of NRCS models for small watersheds. *Journal of the American Water Resources Association*, 37(4), 899–912.

Ferreyra, C., de Loë, R., and Kreutzwiser, R. (2008). Imagined communities, contested watersheds: Challenges to integrated water resources management in agricultural areas. *Journal of Rural Studies*, 24(3), 304–321.

Gao, G. y, Fu, B. J., Lü, Y. H., Liu, Y., Wang, S., and Zhou, J. (2012). Coupling the modified SCS-CN and RUSLE models to simulate hydrological effects of restoring vegetation in the Loess Plateau of China. *Hydrology and Earth System Sciences*, 16(7), 2347–2364.

Gasser, J. (2009). Variation of land degradation indicators on cultivation land within a year. A case study in a commune of the Swiss Plateau in 2008 using field observation methods. *MSc Thesis.* Centre for Development and Environment CDE, Bern.

Government of Tajikistan. (2008). National Disaster Risk Management Strategy for the Republic of Tajikistan 2008-2015.Dushanbe, Tajikistan.

Heltberg, R. and Bonch-Osmolovskiy, M. (2011). Mapping Vulnerability to Climate Change. Policy Research Working Paper, (5554). The World Bank, Washington DC.

Hoeck, T., Droux, R., Breu, T., Hurni, H., and Maselli, D. (2007). Rural energy consumption and land degradation in a post-Soviet setting – an example from the west Pamir mountains in Tajikistan, XI(1). Centre for Development and Environment CDE, Bern.

Huang, M., Gallichand, J., Wang, Z., and Goulet, M. (2006). A modification to the Soil Conservation Service curve number method for steep slopes in the Loess Plateau of China. *Hydrological Processes*, 20(3), 579–589.

Huang, M., Gallichand, J., and Zhang, P. (2003). Runoff and sediment responses to conservation practices: Loess Plateau of China. *Journal of the American Water Resources Association*, 1197–1207.

Hurni, H., Herweg, K., Portner, B., and Liniger, H. (2007). Soil Erosion and Conservation in Global Agriculture. Land Use and Soil Resources. In: A. Braimoh and P. Vlek, (Eds.). Springer Verlag, Berlin.

IAASTD. (2013). Towards Multifunctional Agriculture for Social , Environmental and Economic Sustainability. International Assessment of Agricultural Knowledge, Science and Technology for Development IAASTD. Nairobi, Kenya.

Kienzler, K. M., Lamers, J. P. A., McDonald, A., Mirzabaev, A., Ibragimov, N., Egamberdiev, O.,and Akramkhanov, A. (2012). Conservation agriculture in Central Asia—What do we know and where do we go from here? *Field Crops Research*, 132, 95–105.

Kosmas, C., Danalatos, N., Cammeraat, L. H., Chabart, M., Diamantopoulos, J., Farand, R.,and Vacca, A. (1997). The effect of land use on runoff and soil erosion rates under Mediterranean conditions. *Catena*, 29(1), 45–59.

Lal, R. (1997). Degradation and resilience of soils. Phil. Trans. Royal Society of London, (352), 997–1010.

Ledermann, T., Herweg, K., Liniger, H. P., Schneider, F., Hurni, H., and Prasuhn, V. (2010). Applying erosion damage mapping to assess and quantify off-site effects of soil erosion in Switzerland. *Land Degradation & Development*, 21(4), 353–366.

Lehmann, C. (2003). River Bank Protection Project Muminabad District, Kulyab area, Khatlon Oblast, Tajikistan. Caritas Schweiz Tajikistan, Dushanbe.

Lehmann, P., de Picciotto, G., Wieser, R., Solari, G., Egger, J., and Friedländer, R. (2008). SDC Guidelines on Disaster risk reduction. Swiss Agency for Development and Cooperation SDC, Bern.

Liniger, H., Schwilch, G., Gurtner, M., Mekdaschi Studer, R., Hauert, C., van Lynden, G., and Critchley, W. (2008a). A Framework for Documentation and Evaluation of Sustainable Land Management Technologies. WOCAT Questionnaire. TECHNOLOGIES. Centre for Development and Environment CDE, Bern.

Liniger, H., van Lynden, G., Nachtergaele, F., and Schwilch, G. (2008b). Mapping Land Degradation and Sustainable Land Management. (QM). Centre for Development and Environment CDE, Bern.

Lioubimtseva, E., Cole, R., Adams, J., and Kapustin, G. (2005). Impacts of climate and land-cover changes in arid lands of Central Asia. *Journal of Arid Environments*, 62(2), 285–308.

Local Development Committee Muminabad, LDC., and Caritas Switzerland, LDM. (2006). District Development Plan Muminabad. Action Plans, Information, Addresses. The Five Muminabad Goals. Dushanbe.

Ludi, E. (2002). Economic Analysis of Soil Conservation: Case Studies from the Highlands of Amhara Region, Ethiopia. *PhD Dissertation*. Centre for Development and Environment CDE, Bern.

Märker, M., Angeli, L., Bottai, L., Costantini, R., Ferrari, R., Innocenti, L., and Siciliano, G. (2008). Assessment of land degradation susceptibility by scenario analysis: A case study in Southern Tuscany, Italy. *Geomorphology*, 93(1-2), 120–129.

Milne, E. (2012). Soil organic carbon. In The encyclopedia of earth. http://www.eoearth.org/view/article/156087/, Access: 12.12.2013

Mullan, D. (2013). Catena Soil erosion under the impacts of future climate change□: Assessing the statistical significance of future changes and the potential on-site and off-site problems. *Catena*, 109, 234–246.

Oxfam. (2011). Climate change investment through the Pilot Programme for Climate Resiliance in Tajikistan. Oxfam GB, Dushanbe, Tajikistan.

Prasuhn, V., and Fischer, M. (2007). Wieviel Erde geht verloren? UFA- Revue, 11. Pp. 37-44. Research Station Agroscope Reckenholz-Tänikon ART, Bern.

Pulido-Fernández, M., Schnabel, S., Lavado-Contador, J. F., Miralles Mellado, I., and Ortega Pérez, R. (2013). Soil organic matter of Iberian open woodland rangelands as influenced by vegetation cover and land management. *Catena,* 109, 13–24.

Ravallion, M., Chen, S., and Sangraula, P. (2008). Dollar a Day Revisited. Policy Research Working Paper. The World Bank, Washington DC.

Riegg Cellini, S., and Kee, J. (2010). Cost-effectiveness and Cost-benefit analysis. In J. Wholey, H. Hatry, and K. Newcomer (Eds.), Handbook of Practical Program Evaluation (Third Edition), pp. 493–530. Jossey-Bass, San Francisco, United States:.

Ruppen, S. (2012). A Systemic Biomass Management Analysis of Small-Scale Farmers in the Hill-Zone of Western Tajikistan. *MSc Thesis*. Centre for Development and Environment CDE, Bern.

Schwilch, G. (CDE), Bachmann, F. (CDE), Gabathuler, E. (CDE), & Liniger, H. (CDE). (2013). Appraising and Selecting SLM Strategies A methodology based on stakeholder participation and global best practices. Retrieved from https://www.wocat.net/en/methods/decision-support.html, Access 12.12.2013

Séguis, L., Cappelaere, B., Milési, G., Peugeot, C., Massuel, S., and Favreau, G. (2004). Simulated impacts of climate change and land-clearing on runoff from a small Sahelian catchment. *Hydrological Processes*, 18(17), 3401–3413.

Shepherd, G., and Jannsen, H. (2000). Visual Soil Assessment. Field guide for hill country land uses. Volume 3. 48p. Horizons.mw and Landcare Research, Palmerston North, New Zealand.

Shigaeva, J., Wolfgramm, B., and Dear, C. (2013). Sustainable Land Management in Kyrgyzstan and Tajikistan: A Research Review, (2).Mountain Societies Research Institute, University of Central Asia

Smeets, E., and Weterings, R. (1999). Environmental indicators: Typology and overview. Technical report (25). Centre for Strategy, Technology and Policy TNO, the Netherlands.

Sosin, P. M. (2011). Report on Watershed managament project of Natural Disaster Risk Management in Muminabad district. Dushanbe, Tajikistan.

Sosin, P. M. (2012). Land degradation in Obishur and Chukurak�: problems and solutions. Dushanbe, Tajikistan.

Strahm, A. (2011). Land cover and land use analysis in Muminabad District , Tajikistan , using GIS. *MSc Thesis*. Centre for Development and Environment CDE, Bern.

Studer, S. (2014). An assessment of Sustainable Land Management (SLM) in the loess hills of central Tajikistan using WOCAT tools and DESIRE guidelines. *MSc Thesis*. Centre for Development and Environment CDE, Bern.

Swarup, A. (Oxfam). (2009). Reaching Tipping Point? Climate Change and Poverty in Tajikistan Contents. Oxfam International, Dushanbe, Tajikistan.

TAJSTAT. (2013). Tajikistan in figures 2013, 167. Retrieved from http://www.stat.tj/en/img/ad0df465351c083293dff8839095681b_1378536749.pdf, Access 12.12.2013

The World Bank. (2008). Tajikistan Country Environmental Analysis. Report, (43465-TJ). The World Bank, Washington DC.

UNISDR. (2007). Words Into Action: A Guide for Implementing the Hyogo Framework. p. 166. United Nations International Strategy for Disaster Reduction UNISDR. Geneva.

UNISDR. (2010). Climate Change Adaptation and Disaster Risk Reduction Institutional and Policy Landscape in Asia and Pacific - International Strategy for Disaster Risk Reduction UNISDR, Geneva.

UNEP. (2006). Tajikistan: State of the Environment 2005. United Nations Environment Programme UNEP, Nairobi, Kenya.

United Nations. (1987). Our Common Future. Report of the World Commission on Environment and Development. United Nations, NewYork.

USDA SCS. (1986). Urban hydrology for small watersheds TR-55. Technical Release. United States Department for Agriculture Soil Conservation Service, Washington DC.

Vanselow, K. A., Kraudzun, T., and Samimi, C. (2012). Grazing Practices and Pasture Tenure in the Eastern Pamirs. *Mountain Research and Development*, 32(3), 324–336.

Vlieghe, P. (2012). Integrated Watershed Management Muminabad - Hydrological analysis of the Obishur and Chukurak watersheds. Caritas Switzerland, Dushanbe, Tajikistan.

WFO. (2012). WFO recommendations for eliminating rural poverty and achieving food security. World Food Organization, Rome.

Wolfgramm, B, Shokirov, Q., and Liniger, H. (2012). SDC DRR Programme in Central Asia (Tajikistan): Initiative on Community-Based DRR through Integrated Watershed Management (IWSM) External technical support for KM (knowledge management) SLM Decision Support Workshop, 2-4 May 2012, Muminabad, Tajikistan. *Workshop report*. Centre for Development and Environment CDE, Bern.

Wolfgramm, B, Stevenson, S., Lerman, Z., and Liniger, H. (2011). Tajikistan Pilot Programme for Climate Resilience Component A5: Phase 1 Agriculture & Sustainable Land Management Final report , 15 December 2011. Final report World Bank. The World Bank, Washington.

Wolfgramm, Bettina. (2007). Land Use, Soil Degradation and Soil Conservation in the Loess Hills of Central Tajikistan. *PhD Dissertation*. Centre for Development and Environment CDE, Bern.

ANNEX - 1

Fragebogen

Aufwand und Ertrag auf verschiedenen Landnutzungstypen

Lieber Mitwirkender, liebe Mitwirkende, herzlichen Dank für Ihre Partizipation an dieser Umfrage. Ihre Ernte wurde inzwischen hoffentlich erfolgreich eingeholt. Mit diesem Fragebogen möchte die Universität Bern Informationen über den Aufwand und den Ertrag auf ihren Feldern aufnehmen. Damit soll die Effizienz der verschiedenen Landnutzungstypen in der Jamoat Javonon erfasst werden.

Personaldaten

Familienname: ________________________________

Hausherr: ______________________________________

Anzahl Erwachsene im Haushalt: ___________

Anzahl Kinder im Haushalt: _________________

Haustiere

Anzahl Tiere pro Familie:	Kühe:___________________
Geißen:_________________	Pferde:__________________
Schafe: __________________	Esel:_____________________

Feldinformationen

Im folgenden Abschnitt sollten die Fragen nur für eines von Ihnen bewirtschafteten Felder ihrer Wahl ausgefüllt werden. Bitte kreuzen Sie den Nutzungstyp an für den Sie die Fragen beantworten:

☐Obstgarten ohne Zwischenfruchtbau	☐Heuen bewässert
☐Obstgarten mit Zwischenfruchtbau	☐ Heuen nicht bewässert
☐Weinbau	☐Alfa-Alfa
☐Weizen	☐Esparcette
☐Flachs	☐Alfa-Alfa und Esparcette
☐Kichererbsen	☐Sonstiges: __________________
☐Gemüse	

Wie stark ist das Gefälle dieses Feldes? ☐ 0°-9° ☐ 9°-17° ☐ >17°

Grösse des Feldes: _________________________Hektaren

Input

Wie viele Personen arbeiteten in dieser Saison (2012) auf dem Feld?

a) Anzahl Familienmitglieder: _____________ b) Anzahl Angestellte: _______________________

Wie viele Arbeitstage wurde pro Person in diesem Jahr durchschnittlich in das Feld investiert? (Angestellte und Familienmitglieder)______________________Tage pro Person

Wie viel Gehalt erhielt die angestellte Person pro Tag? _____________________TS

Wie viele Ausgaben hatten Sie in dieser Saison für das Feld für ...

a) ...Maschinen? _________________TS

b) ...Saatgut? ____________________TS

c) ...Düngemittel? ______________TS

Output

Auf Obstgärten und bei Baumreihen wurden allenfalls verschiedene Früchte geerntet. Bitte verwenden Sie für jede Sorte eine Zeile.

Was wurde auf dem Feld geerntet?	Wie viel Kilogramm wurde geerntet?	Was ist der Marktpreis für das Produkt pro kg?	Wie viel kg wurde davon auf dem Markt verkauft?
______________________	______________________	______________________	______________________
______________________	______________________	______________________	______________________

Besten Dank für Ihre Teilnahme!

ANNEX – 2

Visual Field assessment

Legend		1 = poor soil quality	2 = fair soil quality	3 = good soil quality
Soil properties	**Soil erosion**	>50%	25-50%	< 25%
	Surface relief	deeply broken& penetrated	broken up& penetrated	smooth& unbroken
	Surface erosion	Strong	Moderate	Light
Knife Test	**depth**	mm's- mm	1cm	>cm
Picture 1x1 grid	**% veg cover**	<50%	50-75%	>75%

Note:

Pastures: 8 plots à 5 knife tests and à 1 picture: 40 tallies for knife test, 8 tallies for vegetation cover

Orchards, Croplands: 5 plots à 5 knife tests and à 1 picture: 25 tallies for knife test, 5 tallies for vegetation cover

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Technology
Code
Date

	Soil erosion	Surface relief	Surface relief	Average
Soil properties				

	mm('s)	cm	> cm	Average
Knife test				

	< 50 %	50 - 75 %	75 - 100 %	Average class
Vegetation cover				

Total Average

Mixed fruit tree orchard with intercropping of Esparcet and annual crops in Muminabad District
Tajikistan - Bog

left: Agroforestry plot in the front and degraded landscape in the background (Photo: Q. Shokirov)
right: Live fence with hawthorn trees protecting from intruders from the roadside (Photo: Q. Shokirov)

Orchard based agroforestry established on the hill slopes of Muminabad

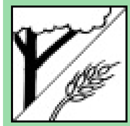
Between 1993 and 94 an individual farmer initiated an orchard by planting a mix of fruit trees, such as apricots, walnuts, cherries, almonds and mostly apple trees in the rainfed hill zones of Muminabad District. In the first couple of years 416 newly planted seedlings were watered manually: water was brought by trucks near to the plot and distributed to the seedlings with buckets. The orchard was established on the existing grazing land and therefore the seedlings had to be secured with a fence from livestock grazing nearby. First hard wire was used for fencing. Simultaneously, hawthorns (Dulona in Tajik) were planted along the fence in order to provide even stronger protection and establish a live fence for the future. Now, the fruit trees are fully-grown and fruits can be harvested every year. The farmer prunes trees annually, which is the key for fruit production. The farmer pointed out that in rainfed areas soils contain less nutrients and usually big trees do not produce high yield. Furthermore, pruned tree branches are used as firewood. The farmer also applies the pesticides B52 and B58, three times a year in the months of April, May and June. The total area of the plot is 1.03 hectares, whereof 0.60 hectares are orchard; Esparcet is covering roughly 0.30 hectares, 0.07 hectare is for haymaking and the rest of the 0.06 hectares is used for growing chickpea and wheat. There is also a road for machinery to pass and to turn around when plowing the land.
Shortly after the fall of the Soviet Union, the government officials distributed land to the villagers. The farmer always had a big interest to establish a small orchard and he obtained little more than a hectare of land. It is his project for retirement. He and his family worked hard throughout the establishment phase. They experimented by planting a variety of vegetables including melons and watermelons. The wild animals ate many of the vegetables and melons, what resulted in the farmer's idea of intercropping Esparcet.
According to the farmer, the first two years were very labor intensive and crucial to establish the orchard. He also had to face a challenge posed by the community, as overnight people from the nearby villages stole roughly 100 of his newly planted seedlings. This is one of the reasons why the farmer had to plant hawthorn in order to establish a live fence. In summary: The establishment phase included planting of young seedlings; manually watering for the first two years; plowing in between the tree rows by machinery; building a fence around the plot and planting/sowing hawthorns. Maintenance activities consist of the following activities: planting new seedlings; pruning of existing trees; grafting new sorts of trees, plowing by tractor in between the tree rows annually; chickpea and wheat cultivation; application of chemical pesticides three times a year. For cutting wheat, the farmer gets support from his son and friends. Every day, he goes to his orchard, which is located at a distance of more than 1.5km from his house. When this technology was documented he was about to build a small clay hut in his orchard. It should be noted that the terrace structure was not implemented at once, but over the years tilling in between the tree rows along the contour lines formed terrace shaped rows. The structure of terraces has been built over the years by tilling in between tree rows along the contour lines.
Muminabad is situated in the southwest of Tajikistan (Khatlon Province) and its hills are covered by loessial soil. Winter temperatures are low and the amount of precipitation is high. Summers are very hot and dry. The growing season lasts from March/ April to September/ October.

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 0.01 km^2
Conservation measure: vegetative, management
Stage of intervention: prevention of land degradation, mitigation / reduction of land degradation
Origin: Developed through land user`s initiative, 10-50 years ago
Land use type:
Mixed: Agroforestry
Land use:
Grazing land: Extensive grazing land (before), Mixed: Agroforestry (after)
Climate: subhumid, temperate
WOCAT database reference: T_TAJ043en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-07-09
Contact person: Sa'dy Odinashoev, Caritas Switzerland, Muminabad, Tajikistan

Classification

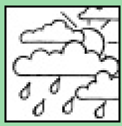
Land use problems:
- Soil erosion by water, heavy rainfalls, absence of vegetative cover on the hill slopes. (expert's point of view)
Soil erosion by water, extensive grazing, gully erosion. (land user's point of view)

Land use



Agroforestry
Grazing land: Extensive grazing land (before)
Mixed: Agroforestry (after)
rainfed

Climate

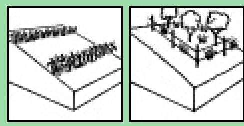


subhumid

Degradation

Soil erosion by water: loss of topsoil / surface erosion, gully erosion / gullying

Conservation measure



vegetative: Tree and shrub cover
management: Change of management / intensity level

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: 10-50 years ago
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: soil management, deforestation / removal of natural vegetation (incl. forest fires), over-exploitation of vegetation for domestic use, overgrazing
Indirect causes: land tenure, governance / institutional

Main technical functions:
- control of raindrop splash
- control of dispersed runoff: retain / trap
- control of dispersed runoff: impede / retard
- improvement of ground cover
- water harvesting / increase water supply
- increase of biomass (quantity)

Secondary technical functions:
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- increase in organic matter
- increase / maintain water stored in soil
- reduction in wind speed

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 180 days (April-Sept/oct)
Soil texture: coarse / light (sandy)
Soil fertility: low
Soil drainage/infiltration: medium

Soil water storage capacity: medium
Ground water table: > 50 m
Availability of surface water: poor / none
Water quality: unusable
Biodiversity: medium

Tolerant of climatic extremes: seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms
Sensitive to climatic extremes: temperature increase, seasonal rainfall decrease, floods, droughts / dry spells

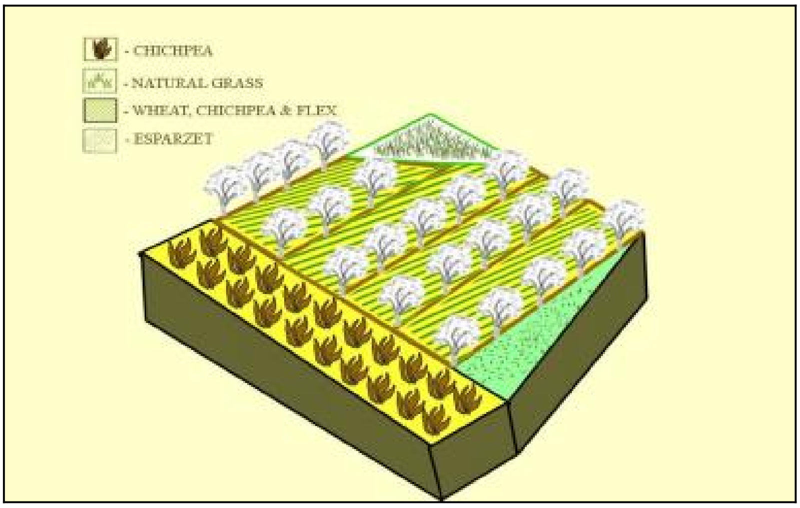
Human Environment

Mixed per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, men and women
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: state
Land use rights: leased (Land ownership is based on the land user certificate conferred by the government.)
Water use rights: (Land ownership is based on the land user certificate conferred by the government.)
Relative level of wealth: average, which represents 40% of the land users;

Importance of off-farm income: 10-50% of all income:
Access to service and infrastructure: low: employment (eg off-farm), energy, financial services; moderate: health, education, technical assistance, market, roads & transport, drinking water and sanitation
Market orientation: subsistence (self-supply)



Technical drawing

The fenced plot is mainly used for the orchard intercropped with chickpea, flax and wheat. Esparcet and grass for haymaking covers only a small part of the plot. The part on the left handside is also used to turn the tractor when ploughing, which is why this part is affected by soil erosion and rills. The whole property is fenced by hawthorns (dulona). The orchard has a terrace-like structure due to annual plowing by tractor. (Q. Shokirov)

Implementation activities, inputs and costs

Establishment activities

-
- Digging a deep barrier for protection around the plot with a bulldozer, 1 day
- Plowing in between the rows by tractor, labor, petrol and rent for one day
- Planting fruit trees, 3 days by 3 persons (3-5 Somoni per seedling, 3 Som/ seedling planting)
- Watering young seedlings for the first couple of years by truck (60 TJS per truck)
- Construction of fence with hard wire and haw thorn (approx. 320m)
- Buying and replanting of 100 stolen fruit seedlings

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1523.70	100%
Equipment		
- machine use	3336.80	100%
- petrol	38.00	100%
Construction material		
- fence	776.30	100%
Agricultural		
- seedlings	534.20	100%
TOTAL	**6209.00**	**100.00%**

Maintenance/recurrent activities

- Tractor ploughing, labor, petrol and rent, 1-2 hours, 2 persons
- Soil loosening around trees, 5-6 days, 3-4 persons
- Pruning of the approx. 400 fruit trees (3 TJS per tree)
- Bringing water from village and watering (40 liters a day,20l on each donkey, 3 h for walking and watering)
- Applying pesticides, 1 person, 7 days (5 hours per day)
- Sowing wheat and chickpea (1 person, 2 hours)
- Cutting wheat and chickpea (2 persons, 4 hours)
- Harvesting fruit trees (3.6 TJS per fruit tree)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	4493.50	100%
Equipment		
- machine use	10.30	100%
- petrol	38.00	100%
Agricultural		
- seeds	6.20	100%
- pesticides	77.50	100%
TOTAL	**4625.50**	**100.00%**

Remarks:
The technology was established during the Soviet Union and most of the expenses were calculated on the price basis of that time. If technology is priced by current prices, the total sum would be very high and no farmer would be able to afford. Thus, current prices were not identified. Nowadays, machinery cost, buying hard wire for fencing and buying seedlings would be the most costly factors.

Assessment

Impacts of the Technology

Production and socio-economic benefits

- ++ increased crop yield
- ++ increased fodder quality
- ++ reduced expenses on agricultural inputs
- ++ increased farm income
- + increased fodder production
- + increased wood production
- + reduced demand for irrigation water
- + diversification of income sources
- + increased production area

Production and socio-economic disadvantages

- +++ establishment costs
- + increased labour constraints

Socio-cultural benefits

- + increased recreational opportunities
- + improved conservation / erosion knowledge

Socio-cultural disadvantages

- ++ risk of theft

Ecological benefits

- ++ reduced surface runoff
- ++ increased biomass above ground C
- ++ reduced soil loss
- + reduced hazard towards adverse events
- + improved soil cover
- + increased soil organic matter / below ground C
- + reduced soil crusting / sealing
- + increased / maintained habitat diversity

Ecological disadvantages

Off-site benefits

- + reduced downstream flooding
- + improved buffering / filtering capacity

Off-site disadvantages

Contribution to human well-being / livelihoods

+

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	neutral / balanced	very positive
Maintenance / recurrent	neutral / balanced	very positive

After 6 years income is very comparable to the establishment cost

Acceptance / adoption:

98% of land user families have implemented the technology with external material support.
2% of land user families (5 families; 10% of area) have implemented the technology voluntary.
There is little trend towards (growing) spontaneous adoption of the technology. Cost of the technology is very expensive, which discourages farmers to implement orchards based agroforestry.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Compared to other plots with orchards there is almost no soil erosion which is mainly due to good land management practices, e.g. the slow building up of terraces. → Sustain the practice of contour ploughing	Since the orchard is located in a rainfed area, hot summer months make the technology vulnerable to drought. To some extent the technology is tolerant to dryer summers, but maybe not for prolonged droughts (e.g. two successive drought). → The farmer has suggested that grafting fruit trees on native hawthorn (dulona) trees has potential for farmers when establishing orchards in rainfed areas. In extreme events (extremely dry years), the farmer brings water for supplementary irrigation from his house by donkey.
Grafting trees especially apple and pear trees on native hawthorns is an affordable and sustainable way of creating orchards in semi-arid areas with rainfed agriculture. Hawthorn is a plant adjusted to dry areas with strong and deep roots, which endures the hot summer months. → Tree nursery workshops and educational programmes about local species through seed associations	It is expensive to establish such orchards nowadays, because of the high cost for purchasing seedlings and hiring other machinery. → See comment below
Intercropping wheat, chickpea, flax and Esparcet in between the tree rows gives an extra economic incentive and also improves land productivity. → Knowledge raising, inspection of those good practices by other farmers	Growing new seedlings and grafting trees is a cheaper way of establishing a new orchard, but it is not commonly practiced among the farmers in the region. → There should be a tree nursery workshop in order to raise awareness among the young generation of farmers.
Haymaking with natural grass and Esparcet provide the farmer with an opportunity to produce hay for the winter months for his livestock, so that he does not need to purchase it from the market at high costs. →	
The farmer practices pruning on a regular basis to keep the trees in good shape for better fruit production, but also to have sufficient fire wood for the winter months. →	

Silvo-pastoralism: Orchard with integrated grazing and fodder production

Tajikistan

Increased productivity of the land by planting fruit trees and conserving the land by restricting the access of livestock resulting in improved runoff retention

In Soviet times, this area of totally 40 ha comprised terraces and walnut trees in the steep foothills and pastures in the lower and flatter part. After the collapse of the Soviet Era, many similar areas got degraded due to uncontrolled grazing and overuse of natural resources. The area described in this documentation, in contrast, was taken over by a family in 1991. Within the whole area of 40 ha, roads were built to improve the access and 6000 trees were planted, whereof 1200 fruit trees were planted on the pasture, conversing it into an orchard. At present, the 6 ha of orchard are mainly consisting of three types of apple (white, golden and red), some pear and cherry trees. Several trees must have dried out or have been cut, as the farmer counts currently around 1000 fruit trees. The whole orchard is combined with pasture land. The farmer let his livestock graze in the orchard, and cuts the remaining grass in autumn, if there is still left. The integrated orchard with pastureland and fodder production is partially fenced to hinder livestock entering his property. Furthermore, the orchard is within the range of vision which allows the farmer`s family to guard it.

The farmer who is managing the orchard today obtained the property of his father in order to continue the family project by his own initiative. By farming he ensures the livelihood of his family. Hence, he felt responsible to progress and improve the quality of life of his own family. The main reason for establishing the orchard within the grassland and to install fences, was to increase productivity of the land, bringin along beneficial effects on soil quality. According to his land users certificate, the main purpose of this land is to provide the local market with food products.

After planting, some of the seedlings were stolen or eaten by livestock from neighbouring farms. Initial labour input in the newly established orchard consisted of getting and planting the seedlings and applying pesticides. The trees are being maintained by pruning. Soil is loosened and drainage provided to increase water infiltration and to protect the trees additionally from parasites. The pasture is grazed by the livestock of the farmer. As the family only has a small number of livestock, grass is cut afterwards and used as fodder. Half of the fodder harvest belongs to the hired worker, the other half belongs to the farmer. The other tasks are executed by the farmer and his family.

The climate is semi-arid with precipitation (800mm totally) mainly during winter and spring time. Altitude is around 1380 m asl. The plot is located at the foothill, with the wider riverbed and fan downstream and overgrazed hills upstream. Bordering with the property from above, a steep slope with a dense vegetation of grafted fruit trees and walnut trees stabilizes the soil.The farmer is living with the family on the property, near the village of Momandion. In the past many livestock from nearby entered the property and grazed there. Through better control and fences less livestock is entering. The property is located directly on the road to Muminabad, the center of the District with a market- 2 km away.Considering the establishment costs of the orchard, the farmer is a fairly whealthy man, nevertheless he had to rely on his family and friends in terms of the working input.The establishment phase was a time and money consuming

left: Apple trees with the house of the farmer in the background (Photo: Malgorzata Conder)
right: Orchard with integrated grazing (Photo: Malgorzata Conder)

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 0.06 km^2
Conservation measure: vegetative, management
Stage of intervention: prevention of land degradation
Origin: Developed through land user`s initiative, 10-50 years ago
Land use type:
Grazing land: Extensive grazing land
Land use:
Grazing land: Extensive grazing land (before), Mixed: Silvo-pastoralism (after)
Climate: subhumid, temperate
WOCAT database reference: T_TAJ044en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-07-19
Contact person: Sa'dy Odinashoev, Caritas Switzerland, Muminabad, Tajikistan

NCCR north south

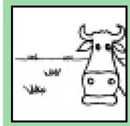
Classification

Land use problems:

- No major problems because of the early implementation of the technology which prevented the area of being (over)grazed without control (expert's point of view)

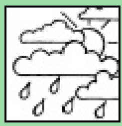
The farmer is afraid of a possible landslide on his property. Another issue is the lack of a continuous fence, because still some unwanted livestock is able to enter the orchard. He installed a water point next to his house recently. (land user's point of view)

Land use



Extensive grazing land
Grazing land: Extensive grazing land (before)
Mixed: Silvo-pastoralism (after)
agropastoralism
rainfed

Climate

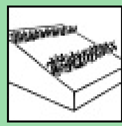
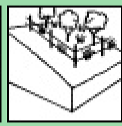


subhumid

Degradation

Soil erosion by water: offsite degradation effects

Conservation measure

vegetative: Tree and shrub cover
management: Change of land use type
management: Change of management / intensity level

Stage of intervention

Prevention
Mitigation / Reduction
Rehabilitation

Origin

Land users initiative: 10-50 years ago
Experiments / Research
Externally introduced

Level of technical knowledge

Agricultural advisor
Land user

Main causes of land degradation:
Direct causes - Human induced: overgrazing

Main technical functions:
- control of concentrated runoff: retain / trap
- control of concentrated runoff: impede / retard
- control of concentrated runoff: drain / divert
- improvement of ground cover
- improvement of topsoil structure (compaction)
- spatial arrangement and diversification of land use

Secondary technical functions:
- control of raindrop splash
- control of concentrated runoff: retain / trap
- control of dispersed runoff: impede / retard
- stabilisation of soil (eg by tree roots against land slides)
- increase in organic matter
- increase in nutrient availability (supply, recycling,…)
- increase / maintain water stored in soil
- increase of groundwater level / recharge of groundwater
- increase of biomass (quantity)

Environment

Natural Environment

Average annual rainfall (mm)

> 4000 mm
3000-4000 mm
2000-3000 mm
1500-2000 mm
1000-1500 mm
750-1000 mm
500-750 mm
250-500 mm
< 250 mm

Altitude (m a.s.l.)

> 4000
3000-4000
2500-3000
2000-2500
1500-2000
1000-1500
500-1000
100-500
<100

Landform

plateau / plains
ridges
mountain slopes
hill slopes
footslopes
valley floors

Slope (%)

flat
gentle
moderate
rolling
hilly
steep
very steep

Soil depth (cm)

0-20
20-50
50-80
80-120
>120

Growing season(s): 180 days (April-Sept/Oct)
Soil texture: medium (loam)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: medium

Soil water storage capacity: high, medium
Ground water table: < 5 m
Availability of surface water: poor / none
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms, floods
Sensitive to climatic extremes: temperature increase, seasonal rainfall decrease, droughts / dry spells, decreasing length of growing period

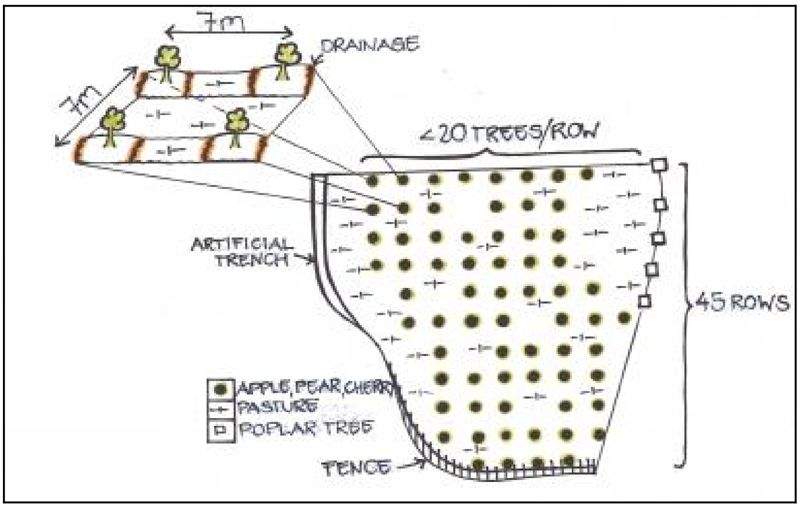
Human Environment

Grazing land per household (ha)

	<0.5
	0.5-1
	1-2
■	2-5
	5-15
	15-50
	50-100
	100-500
	500-1,000
	1,000-10,000
	>10,000

Land user: Individual / household, medium scale land users, common / average land users, mainly men
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: state
Land use rights: leased (Land ownership is based on the land user certificate conferred by the government.)
Water use rights: individual (Land ownership is based on the land user certificate conferred by the government.)
Relative level of wealth: rich

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low: technical assistance, employment (eg off-farm), energy, drinking water and sanitation, financial services; moderate: health, education, market, roads & transport
Market orientation: mixed (subsistence and commercial)
Livestock density: 50-100 LU /km2



Technical drawing

The orchard is situated within the farmers' property which is almost completely fenced by an artificial trench, thornbush fences, poplar trees and a natural steep slope. The orchard is 6 ha in size and consists of around 45 rows, with some 20 trees per row on average. In some places trees are missing due to drying out or cutting. Currently approximately 1000 fruit trees are growing. In between the tree rows and at the borders of the orchard, grass is growing and grazed by animals, and if not entirely grazed cut for haymaking in autumn. The fruit trees grow at a distance of 7 meters. Around the trees the soil is loosened and a tiny trench is dug, the latter serving as a rainwater drainage. (Conder Malgorzata)

Implementation activities, inputs and costs

Establishment activities

- Buying and transport of fruit seedlings (totally 6000 seedling, whereof 1200 seedlings on for the orchard of 6 ha)
- Planting fruit tree seedlings (totally 6000 seedlings, whereof 1200 seedlings for the orchard), cost according to planted trees (3 TJS per tree)
- Partial fencing (of around 200m) along the property, 10.5 days, 3-4 persons
- Building roads for access to the house

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	194.90	100%
Equipment		
- machine use	0.70	100%
Construction material		
- fence	124.20	100%
Agricultural		
- seedlings	207.00	100%
TOTAL	**526.80**	**100.00%**

Maintenance/recurrent activities

- Pruning of 400 trees, ca. 40 days, 1 person, 3 TJS per tree (all trees pruned every 3 years)
- Soil loosening around 1000 fruit trees, ca. 25 days (5 h/day), 1 person
- Pesticides spraying once (should be done 2-3 times), 4 days (ca.5 h/d), 1 person
- After several years: Harvesting fruits (mainly apples)
- Cutting grass, by 10 people, one month, hours per day unknown. Half of straw harvest for owner, other half for the mowers as salary (4-5 Somoni/bundle). Total salary: 1000 bandles
- Guarding the orchard

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	383.30	100%
Agricultural		
- pesticides	7.80	100%
TOTAL	**391.10**	**100.00%**

Remarks:
Apart from the orchard, the whole property was rebuilt with roads, fences and tree planting which caused high initial costs during the establishment phase.
The structural fencing is adapted from T_TAJ047. Working hours are approximate as the work was done a long time ago, with the help of many relatives with different work times. No overview over the exact work and cost input exists, tools were mainly borrowed, prices unknown. Road building done in the past was not included, because current costs were difficult to estimate. Work as guardening is not monetarised. Apple harvesting as recurrent activity (vegetative measure) is derived from T_TAJ013. In the cost summary, the fencing was calculated proportionally to one ha.

Assessment

Impacts of the Technology

Production and socio-economic benefits

- +++ increased crop yield
- +++ increased farm income
- ++ increased fodder production
- ++ increased fodder quality
- ++ diversification of income sources
- ++ increased production area
- ++ increased product diversification
- \+ increased wood production
- \+ reduced demand for irrigation water

Production and socio-economic disadvantages

- \+ reduced animal production
- \+ increased risk of crop failure
- \+ increased expenses on agricultural inputs

Socio-cultural benefits

- +++ improved food security / self sufficiency
- ++ improved health

Socio-cultural disadvantages

- \+ less time to think about god

Ecological benefits

- +++ increased biomass above ground C
- ++ improved soil cover
- ++ increased soil organic matter / below ground C
- ++ reduced soil crusting / sealing
- ++ reduced soil compaction
- \+ increased soil moisture
- \+ reduced surface runoff
- \+ reduced soil loss

Ecological disadvantages

Off-site benefits

- \+ reduced downstream flooding
- \+ improved buffering / filtering capacity

Off-site disadvantages

Contribution to human well-being / livelihoods

++ Products for market leading to higher income, sharing of some knowledge about management of private land enhances dissemination and exchange of information/knowledge.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly positive	positive
Maintenance / recurrent	positive	positive

Family project to improve the quality of life of the family. Costs were high at the beginning with little outcomes, now there is less labour required and the outcome is high.

Acceptance / adoption:

There is no trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Thanks to the establishment time, right after the collapse of the Soviet Union, when land was generally well conserved, the technology worked as a preventive measure. → Preventive measures are less laborious and more cost effective than rehabilitation measures.	For the farmer, the economic benefit is more important than the ecologic benefit. Especially, there is missing sensibility of the farmer concerning the application of pesticides (quantity, type). → A workshop which provides guidelines on optimal use of pesticides (type and quantities of pesticides, timing and frequency of application etc.)
Silvopastoralism not only raises productivity of the same plot as an orchard and pasture is combined, but also enables mutual benefits (p.e.rooting system raises soil moisture, which is again improving vegetation cover). → Recurrents activities are the key to maintain the mutual environmental benefits	The establishment of orchards is more efficient on big plots of land, which often prevents poor farmers with small plots from establishing orchards. → Creating incentives to change land use, by combining plots from different land owners, which will allow to share costs for establishment and maintenance. Yields should be clearly attributed to the individual farmers.
The technology might work as exemplary model for other farmers → Organise visits of farmers of the Technology, sharing ideas and experiences between them	There is always work to do, without input no (good) output. →
Giving good yield and "cash crop" hence having success in the project of the family → Maintenance activities are crucial after establishment	
Better quality of fodder and less damages due to intrusive livestock → Maintaining the guarding	

Degraded communal pasture Chukurak
Tajikistan

Degraded communal pastureland without grazing management and sufficient waterpoints

A communal pastureland of 150 -200 hectares is located at the foothill and the riverbank. Around 60 households let their livestock of totally 100 cows and some 400 sheep and goats graze there. The livestock is divided into three groups. Each group is meant to graze at different places in the pastureland. As there is no water point higher up in the pasture area, livestock graze near the village where a water point is installed. Due to this the riverbed, which is already poor in vegetation, is totally overgrazed. Every family is looking after a herd for a day every two month.
The aim is to install more water points higher up in the pastureland to decrease pressure on soil and vegetation cover by improving rotation within the pastureland. The whole land is overgrazed and livestock numbers are increasing, which is why controlled pasture management could be expected to decrease the degradation process. Nevertheless, more vegetation would be available for feeding livestock and the journey to the next water point shortened thus saving the heard's energy. As nobody feels responsible for the pasture, nobody is responsible for pasture. No controlled grazing or rotation plan exists at Jamoat level. The farmers do not organise which parts have been grazed and could be grazed next. The livestock owners pay very small rent so they do not value the pastureland and no money is available to implement projects (like installing water points).
Each of the 60 households is paying 10-12 Somoni per year for grazing their cattle on the communal grazing land. Rent is paid per household not per amount of livestock. The total amount of pasture fees collect in Chukurak village is 600-700 Somoni per year. Neither establishment costs, nor investment or maintenance activities are done. Pastureland extends from the village in the valley, to the foothills. Half of the grazing area is on the riverbed and fan with very poor vegetation cover. The foothills show a high percentage of overgrazed, trampled, eroded area. Except for the water point near the village, no water and shady points exist for resting livestock. Three small water sources existed before, two of them where covered by the floods in spring of the current year. The other source produces a negligible amount of drinking water. 60 households graze their livestock, which totals 100 cows and 400 small livestock. Every household is responsible to graze the herd one day every two month. Except that, no management exists between the families and Jamoat.

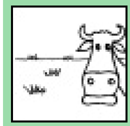
left: Communal pasture affected by livestock trampling (Photo: Conder Malgorzata)
right: Different intensity of overgrazing due to steepness and exposition of the slope (Photo: Conder Malgorzata)

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 2 km^2
Conservation measure: management
Land use type:
Grazing land: Extensive grazing land
Climate: subhumid, temperate
WOCAT database reference: T_TAJ045en
Related approach: Common village herding (TAJ007), Livestock Commitee at Village Level (TAJ013)
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-07-27

Classification

Land use problems:
- Overgrazing, soil compaction, soil and gully erosion, increasing vegetation cover and hence lower resilience for disaster risks (expert's point of view)
Decreasing vegetation cover, increasing disaster risk, decreasing flood and drought resilience, rill and gully formation No water acces in the upper part of the pastureland (land user's point of view)

Land use



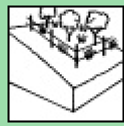
Extensive grazing land
extensive grazing land
rainfed

Climate

subhumid

Degradation

Conservation measure



Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user
- Ingineers

Main causes of land degradation:
Direct causes - Human induced: overgrazing
Indirect causes: land tenure, inputs and infrastructure

Main technical functions:
- improvement of ground cover
- increase of infiltration
- water harvesting / increase water supply

Secondary technical functions:
- control of dispersed runoff: impede / retard
- control of concentrated runoff: impede / retard
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- stabilisation of soil (eg by tree roots against land slides)
- increase in organic matter
- increase in nutrient availability (supply, recycling,...)
- increase / maintain water stored in soil
- sediment retention / trapping, sediment harvesting

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 180 days (March-Sept)
Soil texture: coarse / light (sandy)
Soil fertility: low
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: very low
Ground water table: > 50 m
Availability of surface water: poor / none
Water quality: unusable
Biodiversity: low

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase
Sensitive to climatic extremes: seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods, droughts / dry spells
If sensitive, what modifications were made / are possible: Improved vegetation cover, improved infiltration, slope stabilization and natural disaster resilience Install water points higher up, rotate within the grazing land and less energy needed by livestock, which leads also to less overgrazing

Human Environment

Grazing land per household (ha)

	<0.5
	0.5-1
	1-2
■	2-5
	5-15
	15-50
	50-100
	100-500
	500-1,000
	1,000-10,000
	>10,000

Land user: groups / community, Small scale land users, common / average land users, mainly men
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: communal / village
Land use rights: leased (Land ownership is based on Land user certificates)
Water use rights: communal (organised) (Land ownership is based on Land user certificates)
Relative level of wealth: average

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low: technical assistance, employment (eg off-farm), energy, drinking water and sanitation, financial services; moderate: health, education, market, roads & transport
Market orientation: subsistence (self-supply)
Livestock density: > 100 LU /km2

Technical drawing

Bare vegetation cover, no trees, soil erosion, trampled paths, rill building, no waterpoints are all calling for pasture management among the villages. (Malgorzata Conder)

Implementation activities, inputs and costs

Establishment activities

Maintenance/recurrent activities

Remarks:
Rehabilitation labour (regarding structural measures for DDR for riverbed stabilisation or trees planting) is more cost intensive than preventive measures as pasture management.

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages
	++ reduced animal production ++ reduced wood production + decreased drinking water availability / quality + increased expenses on agricultural inputs + decreased farm income

Socio-cultural benefits	Socio-cultural disadvantages
	+ decreased food security self sufficiency

Ecological benefits	Ecological disadvantages
	+++ increased soil erosion locally ++ increased surface water runoff ++ decreased soil cover ++ increased soil sealing / compaction ++ reduced biodiversity / crop diversity + decreased soil moisture + lowering of ground water table + increased wind velocity + decreased soil organic matter

Off-site benefits	Off-site disadvantages
	++ increased downstream flooding ++ increased damage on infrastructure + decreased buffering / filtering capacity

Contribution to human well-being / livelihoods

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	not specified	not specified
Maintenance / recurrent	not specified	not specified

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Establish rotational grazing, which would not be expensive and does not require further equipment except of organizational tasks. → Empower communication and decision-making between the farmers by regular meetings or round tables on community level	Importance of rotational grazing depends on Jamoat and farmers level → Strengthen communication between Jamoat and Farmer through consultancy, meetings etc. Farmers, as tenants, should also get a voice.
	Pastureland rent is too cheap and it is not valued. There is no incentive to change, because nobody feels responsible for that area. → Increase the rent and discuss communally where the money should be spent (e.g. for water points).
	Pasture management does not show benefits immediately, which makes it difficult to evidence good management. → Awareness raising and increasing knowledge of the short and long-term benefits.
	Installation of water points is crucial, but very costly and hard work. →
	Livestock number should decrease, but it is socioeconomically very important and demands a lot of time to change this attitude. → Awareness rising and find alternatives of investing in livestock.

Degraded communal pasture Obishur
Tajikistan

left: Trampled and eroded area on the communal pastureland (Photo: Conder Malgorzata)
right: Degraded pastureland (Photo: Conder Malgorzata)

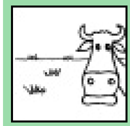
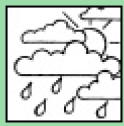
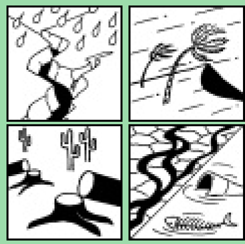
Degraded communal pasture without grazing management and sufficient waterpoints

On the communal pasture, located at the foothill around 85 households graze their livestock totally 500 cows and 100 sheep and goats. Half of the households of the village Momandion have livestock which is meant to graze at different places on that pasture. As there is no water point higher up in the pasture area, livestock grazes near the village where a water point is installed. The rolling zone is totally overgrazed and shows several deep gullies. Cows and the small livestock are divided for grazing. Every family is looking after a herd for a day every month. Although the families of the herding livestock communicate with each other, there is no planning for a sustainable grazing management.
The whole plot is overgrazed and livestock is increasing, so at least controlled pasture management could be expected to decrease the degradation process. Additionally, more vegetation would be available for feeding livestock. More water points have to be installed higher up in the pasture, to decrease pressure on soil and vegetation. More waterpoints would extend the area to be used for grazing. Another issue is that nobody really feels responsible for the pasture and its management. This explains why no pasture management exists at Jamoat level. Farmers are not organized in terms of pasture rotation and control. Livestock owners pay very small rent, which does not make them vakue the pastureland. Additionally, the tax is not enough for projects or investments (like installing water points).
Every household pays 12 Somoni per year for pasture rent, which is in total around 1000 Somoni. Rent is per household not per livestock number. No maintenance is done. The pasture extends from the foothill to the upper parts of the hill with a high percentage of overgrazed, trampled, erosive area. Except for the water point near the village, there is no water and no shady points for livestock. 85 households graze their livestock, which total 1500 cows and small livestock. Every household is responsible for grazing the herd one day every month. Apart from that, no management exists between the families and Jamoat.

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 0.94 km^2
Stage of intervention: rehabilitation / reclamation of denuded land
Land use type:
Grazing land: Extensive grazing land
Climate: subhumid, temperate
WOCAT database reference: T_TAJ046en
Related approach: Livestock Commitee at Village Level (TAJ013), Common village herding (TAJ007)
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-07-28

Classification

Land use problems:
- Overgrazing, soil compaction, soil and gully erosion, increasing vegetation cover and hence lower resilience for disaster risks (expert's point of view)
More livestock reduces vegetation cover through overgrazing and trampling. Gully formation. Not enough water acces in the pastureland. (land user's point of view)

Land use	Climate	Degradation	Conservation measure
			
Extensive grazing land extensive grazing land rainfed	subhumid	Soil erosion by water: loss of topsoil / surface erosion, Soil erosion by wind: offsite degradation effects, Biological degradation: reduction of vegetation cover, Water degradation: change in quantity of surface water	

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: overgrazing
Indirect causes: population pressure, land tenure

Main technical functions:
- control of concentrated runoff: impede / retard
- improvement of ground cover
- stabilisation of soil (eg by tree roots against land slides)
- increase of infiltration

Secondary technical functions:
- control of dispersed runoff: impede / retard
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- increase in organic matter
- increase / maintain water stored in soil
- spatial arrangement and diversification of land use

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 180 days (March-Sept)
Soil texture: coarse / light (sandy)
Soil fertility: low
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: very low
Ground water table: > 50 m
Availability of surface water: poor / none
Water quality: unusable
Biodiversity: low

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase
Sensitive to climatic extremes: seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods, droughts / dry spells
If sensitive, what modifications were made / are possible: Pasture rotation would improve vegetation cover, infiltration, slope stabilization and natural disaster resilience Rotate within the grazing land and less energy needed by livestock, which leads also to less consumption and hence overgrazing

Human Environment

Grazing land per household (ha)

<0.5
0.5-1
1-2
2-5
5-15
15-50
50-100
100-500
500-1,000
1,000-10,000
>10,000

Land user: groups / community, Small scale land users, common / average land users, mainly men
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: communal / village
Land use rights: individual (Land ownership is based on Land user certificates)
Water use rights: leased (Land ownership is based on Land user certificates)
Relative level of wealth: average

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low: technical assistance, employment (eg off-farm), energy, roads & transport, drinking water and sanitation, financial services; moderate: health, education, market
Market orientation: subsistence (self-supply)
Livestock density: 50-100 LU /km2

Technical drawing

Bare vegetation cover, no trees, soil erosion, trampled paths, rill building, no waterpoints are all calling for pasture management among the villages. (Malgorzata Conder)

Implementation activities, inputs and costs

Establishment activities

- Possible solutions: Pasture Management Workshops, Meetings, Round table
- Water points
- Reduce Livestock quantity

Maintenance/recurrent activities

Remarks:
It wouldn not be expensive to hold regular meetings between the livestock keeping families for a better organization of the grazing area. The installation of a water point is very costly and labour intensive in contrast.

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages
	++ reduced animal production ++ reduced wood production + decreased drinking water availability / quality + increased expenses on agricultural inputs + decreased farm income

Socio-cultural benefits	Socio-cultural disadvantages
	+ decreased food security self sufficiency

Ecological benefits	Ecological disadvantages
	+++ increased soil erosion locally ++ increased surface water runoff ++ decreased soil cover ++ increased soil sealing / compaction ++ reduced biodiversity / crop diversity + decreased soil moisture + lowering of ground water table + increased wind velocity + decreased soil organic matter

Off-site benefits	Off-site disadvantages
	++ increased downstream flooding ++ increased damage on infrastructure + decreased buffering / filtering capacity

Contribution to human well-being / livelihoods

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	not specified	not specified
Maintenance / recurrent	not specified	not specified

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Establishment of rotational grazing is not expensive and does not require further equipment → Empower communication and decision-making also between the farmers	Importance of rotational grazing depends on Jamoat and farmers level → Strengthen communication between Jamoat and farmers through consultancy, meetings etc. Farmer as tenants should get a voice.
	Pastureland rent is too cheap and is not valued. There is no incentive to change, because nobody feels responsible for that area. → Increase the rent and discuss communally where money should go to (e.g. water points).
	Pasture management does not show benefits immediately which makes it difficult to evidence good Technology. → Explanation/ education about short and long-term benefits

left: Fenced Alfalfa orchard (Photo: Conder Malgorzata)
right: Harvested bundles of Alfalfa (Photo: Conder Malgorzata)

Orchard establishment on a former wheat plot, by planting fruit tree seedlings in combination with sowing Alfalfa

Tajikistan

Conversion of wheat monocropping into an Alfalfa plot with the aim to establish an orchard

In 2009 the farmer changed his wheat plot into an Alfalfa plot where he also planted fruit tree seedlings in between to establish an orchard. One hectare is used for the perennial cropping of Alfalfa. Alfalfa cropping supplements beneficial soil functions which are crucial for the establishment of an orchard. The plot lies on a narrow plateau next to other wheat crops. The plot is mainly bordered by fruit and nut orchards on a gentle slope, and by a steep slope of the riverbed. A solid fence prevents boars from entering the area through the nut orchard. The plot is not accessible by the steep slope. Two fences are built from the side of the neighboring wheat plots. One fence works like an entrance gate to all the plots on that plateau. A second fence indicates the boundaries between the farmers' Alfalfa crop and the wheat plots belonging to other farmers. The whole family is working on the farm land, consisting of several plots which are distributed over the valley. The children are mainly guarding the cropland.
In order to establish an orchard, first the farmer planted Alfalfa, which maintains more moisture in the soil and hence creates favorable conditions for tree growth. The wheat cropping was drying out the soil. Therefore during heavy rainfall events water infiltration was limited, and the strong runoff washed away the wheat crop. It was the farmer’s initiative to change the crop management, but Caritas Switzerland supported him with a financial grant. Alfalfa can be harvested several times a year, which he can use as fodder for the livestock or as cash crop.
The first year after the crop rotation there was no benefit, as the Alfalfa did not give any harvest yet. According to the farmer, Alfalfa seeds were relatively cheap (15 TJS per kg) and result in a good harvest. Currently he is harvesting Alfalfa three times a year, wheat could only be harvested once a year. The whole family was involved in the establishment of the alfalfa crop and tree planting, by ploughing, sawing Alfalfa, planting the seedlings and constructing the fence. Despite the fence, the crop is often guarded by the farmer or his children because boars enter his property. After the first year some seedlings dried out which he had to replace. Presently, little maintenance is required, only guarding and cutting Alfalfa.
The farmer’s plot is situated on a plateau on the other side of the riverbed, from where the village of Momandion is located. It takes some 15 minutes to get from their house to the plot. One of his neighbors adopted the technology of sowing Alfalfa and planting fruit tree seedlings.

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 0.01 km^2
Conservation measure: management
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed through land user`s initiative, recent (<10 years ago)
Land use type:
Cropland: Annual cropping
Land use:
Cropland: Annual cropping (before),
Mixed: Agroforestry (after)
Climate: subhumid, temperate
WOCAT database reference: T_TAJ047en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-08-09
Contact person: Sa'dy Odinashoev, Caritas Switzerland, Muminabad, Tajikistan

Classification

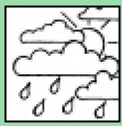
Land use problems:

- Soil erosion, poor nutrient and moisture availability in the soil, high runoff (expert's point of view)
Soil erosion, poor soil moisture availability, high runoff, declining yields (land user's point of view)

Land use

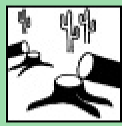
Annual cropping
Cropland: Annual cropping (before)
Mixed: Agroforestry (after)
rainfed

Climate



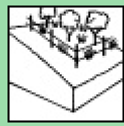
subhumid

Degradation

Soil erosion by water: offsite degradation effects, Biological degradation: reduction of vegetation cover

Conservation measure



management: Change of land use type

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: recent (<10 years ago)
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: crop management (annual, perennial, tree/shrub)
Indirect causes: poverty / wealth

Main technical functions:
- improvement of ground cover
- increase in organic matter
- increase in nutrient availability (supply, recycling,...)
- increase / maintain water stored in soil
- spatial arrangement and diversification of land use

Secondary technical functions:
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- increase of infiltration

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 180 days (April-Sept/Oct)
Soil texture: medium (loam)
Soil fertility: high
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: high
Ground water table: 5 - 50 m
Availability of surface water: poor / none
Water quality: poor drinking water
Biodiversity: medium

Tolerant of climatic extremes: seasonal rainfall increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), droughts / dry spells
Sensitive to climatic extremes: floods, decreasing length of growing period

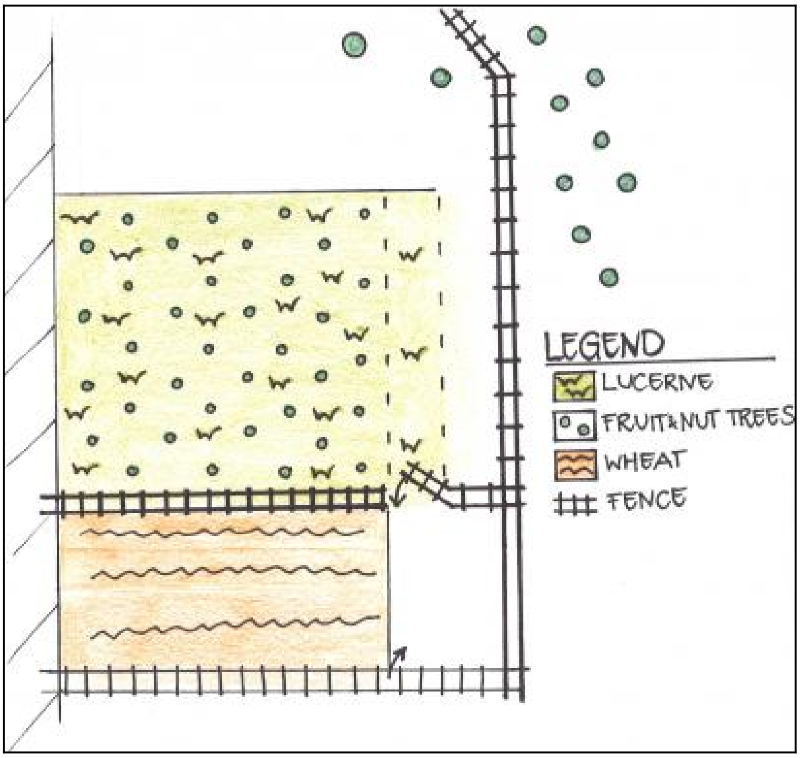
Human Environment

Cropland per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, medium scale land users, common / average land users, mainly men
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: state
Land use rights: leased (Land ownership is based on the land user certificate conferred by the government.)
Water use rights: communal (organised) (Land ownership is based on the land user certificate conferred by the government.)
Relative level of wealth: rich

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low: employment (eg off-farm), energy, roads & transport, drinking water and sanitation, financial services; moderate: health, education, technical assistance, market
Market orientation: subsistence (self-supply)
Mechanization: manual labour
Livestock grazing on cropland: no



Technical drawing

The farmer's property is located on a plateau, surrounded by an upper orchard on a slope (in the top right corner on the figure) and delimited by a steep embankment (on the left on the figure). The Lucerne plot is protected by a fence and the embankment to hinder intrusions of boars. There is a well locked entrance to get to the crop. A second fence protects the adjacent wheat crops and the Lucerne plot. Around 600 fruit trees are planted in the crop leaving a buffer strip of Lucerne. (Malgorzata Conder)

Implementation activities, inputs and costs

Establishment activities

- Plowing - machine hours, rent
- Plowing - petrol, litres
- PLowing - labour light, person day
- Sowing Alfalfa - 5-6 person, 0.33 hours
- Sowing Alfalfa - seeds
- Buying and planting 600 trees: 10 Min/ tree for digging
- After first year: 100 trees dried out
- Fencing 400 m, by 6-7 pers, 10-11 days (8 h a day)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1044.20	37%
Equipment		
- machine use	103.50	37%
- petrol	136.60	37%
Construction material		
- fence	1490.70	37%
Agricultural		
- seeds	62.00	37%
- seedlings	476.20	50%
TOTAL	**3313.20**	**38.87%**

Maintenance/recurrent activities

- Harvesting/Cutting Alfalfa 3 times and seeds 1 time, 8 Pers one week (first cut)
- Soil loosening around 600 trees
- Looking after the orchard, 2 or 5 hours per day
- Pruning after 5 years (in future), one month

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	2613.20	100%
TOTAL	**2613.20**	**100.00%**

Remarks:
Fencing is very expensive due to high material costs. It is a very laborious and time consuming work.
2.5.4.2 Harvesting and cutting labour input is estimated proportinally to the expected yield. The first cut has a max. yield, the second yield amounts up to 70%, the third some 50% of the initial yield. Labour input for harvest might be to high as it was not indicated by hours, but by days. The farmer paid only a part of the initial costs, which amount some 37% of the total costs.

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages
+++ increased crop yield	
+++ increased fodder production	
+++ increased fodder quality	
++ increased farm income	
++ increased product diversification	
+ reduced demand for irrigation water	
+ reduced expenses on agricultural inputs	
+ decreased workload	

Socio-cultural benefits	Socio-cultural disadvantages
+ improved food security / self sufficiency	

Ecological benefits	Ecological disadvantages
++ increased soil moisture	
++ improved soil cover	
++ increased biomass above ground C	
++ increased nutrient cycling recharge	
++ increased soil organic matter / below ground C	
++ reduced soil crusting / sealing	
++ reduced soil compaction	
+ reduced surface runoff	

Off-site benefits	Off-site disadvantages
+ reduced damage on neighbours fields	

Contribution to human well-being / livelihoods

+ Food security and higher income. Technology seems to be adopted by one to two other farmers.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly negative	positive
Maintenance / recurrent	slightly positive	very positive

Alfalfa seeds are more expensive than other seeds (e.g. wheat) and in the first year just one cut can be done. In the second year already several cuts are possible and assure a high yield. It is expensive to establish an orchard and in the first 5 years there is no harvest.

Acceptance / adoption:

There is little trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Alfalfa gives good yield and is a good conservation measure for soil and water. → Workshops or institutional incentives for farmers to promote perennial crops.	First year might result in more input than output because just one cut is possible and an orchard must grow at least 5 years to give fruits. → Raise awareness about long-term benefits or give incentives in the establishment phase.
After one time sowing, several cuts are possible from the second year on. → Spread the experience of the farmer.	
Perennial crops are beneficial to soil and increases the income of the farmer. → Spread technology through demonstrations, work shops etc.	

Pasture management through rotational grazing

Tajikistan

Rotational grazing on private grazing land used as daily pastures

A riverbed divides the pasture where rotational grazing is practiced with the village Chargii poyon, where the certified land user and owner of the pasture lives. From a view point nearby his house, he has a good view on and hence a good control over the pasture area. This allows him to keep intrusive livestock outside, having a limited number of grazing livestock in the pasture. The area encompasses 119 ha, from which 5 ha are rented out as crop land. Land tenure conflicts about this pasture existed over many years, because there wasn't declared any owner. The certified land user of Chargii poyon claims to possess the pasture since 1999. It is unclear how he got the land transferred. Being aware of the ongoing degradation of this land, the certified land user divided the area into 3 parts and introduced controlled grazing in 2007. While one part is being grazed the other two lie fallow. After one to two months of grazing in one area, the herds move to the next area. The rotation phases depend on the availability of grass. In June 2012, at the moment of documentation, there were 145 cows and some 30 goats and sheep. The number of animals is varying seasonally, with a higher amount of animals in summer than in winter. Compared to other pastures in summer, more grass in available on the pasture with rotational grazing. In winter grass availability is comparable between the pastures. This may explain why a higher number of livestock is recorded on the pasture with rotational grazing in summer. The pasture is controlled by the farmer and further 4 people to avoid livestock intrusion. In a seminar organized by Caritas Switzerland, the farmer learned about increasing long-term productivity of pastures by vegetation recovery. The idea of pasture rotation convinced him in order to raise productivity on long-term. The main reasons for changing the pasture management were the advanced stage of deforestation, increasing overgrazing, and the additional source to get the land taxes paid. The management of the pasture by rotational grazing on three areas allows the non-grazed areas to rest and recover. Less grazed and trampled areas result in an increase of the vegetation cover and thus to higher fodder quality, as well as increased soil stability and therefore a reduced risk of disasters, such as floods. The farmer expected that the implementation of land conservation measures would stop the on-going pasture degradation and would assure long-term and sustainable use of the land. Despite the rotating system, the grazing land is still overgrazed and shows signs indicating moderate erosion, but it is less degraded than other pastures in the watershed. The area being the most far away from the settlement is in best conditions. The closer to the riverbed the more degraded and eroded the pasture is. Additional measures are necessary to reduce soil erosion and gully formation in the area

Livestock owners have to pay a fee to the farmer for grazing cows, but not for grazing sheep and goats. The amount of the fee depends on the provenance of the herder. Fees vary greatly between the villages. Because of solidarity, Chargii villagers pay much less than herders from villages located further away. Momandion villagers pay 3 times, Dilolo villagers even 9 times more than Chargi villagers. But the certified land user claims to be flexible in the amount of fees for poor herders. He has to pay taxes to the government for the property and salary to the surveillants. If more money is available, also generated by the fees, the certified land user claims to invest a part of the money into the pasture. He would like to build another water point and to plant trees in the upper area. Livestock could graze in more remote areas which would reduce the pressure on the pastures in the lower area and decrease the soil compaction.

The pasture is located in the middle zone of the Obishur watershed and on the foothill above the riverbed plain. This pasture, located between the villages of Chargi poyon, Chargi bolo and Momandion and not far from Dilolo village, is a reachable place for many livestock of private households. In the riverbed, the only water point is installed where livestock is watered at midday. Due to tree cutting in the past, only a few shady places exist. Vegetation cover varies depending on the exposition of the slopes and the accessibility of the pasture. North-facing slopes have a more abundant vegetation cover. Some flanks are difficult to reach because of dense thorn bushes. A big gully, hardly accessible by livestock, is about to be covered again by naturally re-growing bushes and trees. Nevertheless, signs of erosion and rill building can be observed. Due to the closeness to the villages and to the pressure on natural resources it is crucial to sustain a controlled pasture management.

left: Moderately and heterogenously degraded pasture (Photo: Malgorzata Conder)
right: A few trees and shrubs remaining on the pasture (Photo: Malgorzata Conder)

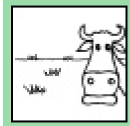
Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 1.14 km^2
Conservation measure: management
Stage of intervention: mitigation / reduction of land degradation
Origin: Developed externally / introduced through project, recent (<10 years ago)
Land use type:
Grazing land: Extensive grazing land
Climate: subhumid, temperate
WOCAT database reference: T_TAJ048en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-09-03
Contact person: Sa'dy Odinashoev, Caritas Switzerland, Muminabad, Tajikistan

Classification

Land use problems:

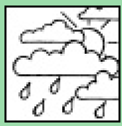
- Overgrazed pasture with frequent big gullies, rills and trampled areas. Almost complete deforestation of the grazing land. (expert's point of view)
Lack of water availability and water points for grazing livestock. Gradual degradation and erosion of the pasture which has to be stopped. (land user's point of view)

Land use



Extensive grazing land
extensive grazing land
rainfed

Climate

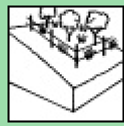


subhumid

Degradation

Soil erosion by water: loss of topsoil / surface erosion, gully erosion / gullying

Conservation measure



management: Change of management / intensity level

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: recent (<10 years ago)
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: overgrazing
Indirect causes: governance / institutional, livestock pressure

Main technical functions:

- control of concentrated runoff: impede / retard
- control of concentrated runoff: drain / divert
- improvement of ground cover
- increase of infiltration

Secondary technical functions:

- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- stabilisation of soil (eg by tree roots against land slides)
- increase in organic matter
- increase / maintain water stored in soil

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 180 days (April-Sept/Oct)
Soil texture: medium (loam)
Soil fertility: medium
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: medium

Soil water storage capacity: low
Ground water table: 5 - 50 m
Availability of surface water: poor / none
Water quality: poor drinking water
Biodiversity: low

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells
Sensitive to climatic extremes: seasonal rainfall decrease
If sensitive, what modifications were made / are possible: Thanks to a better vegetation cover, the infiltration of rainwater is facilitated which results in an increase in soil moisture and thus to a higher resilience to droughts or higher temperatures.

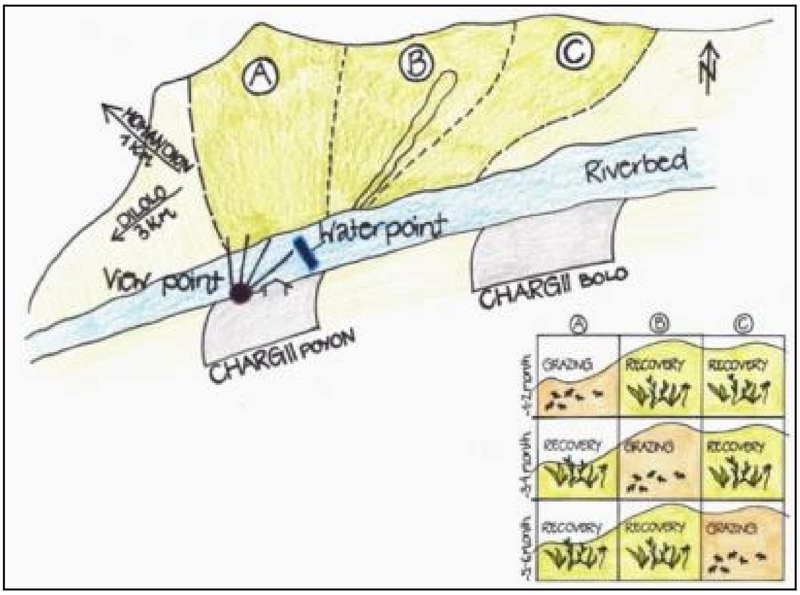
Human Environment

Grazing land per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, medium scale land users, Leaders / privileged, mainly men
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: state
Land use rights: leased (Land ownership is based on the land user certificate conferred by the government.)
Water use rights: communal (organised) (Land ownership is based on the land user certificate conferred by the government.)
Relative level of wealth: rich

Importance of off-farm income: less than 10% of all income: Additionally bee-keeping
Access to service and infrastructure: low: technical assistance, drinking water and sanitation, financial services; moderate: health, education, employment (eg off-farm), market, energy, roads & transport
Market orientation: subsistence (self-supply)
Livestock density: > 100 LU /km2



Technical drawing

The hilly pasture of 114 ha in total is divided more or less vertically in 3 areas. In each area, the pasture between the ridge and the riverbed is covered. After having grazed one area for approximately one to two months, the herd moves to the next part. This means that two areas rest and grasses recover, while one is being grazed. (Malgorzata Conder)

Implementation activities, inputs and costs

Establishment activities

- Introduction/information of pasture management among the herders

Maintenance/recurrent activities

- Salary for 5 people to guard pasture and herders: Monthly salary 70 Som/pers, pers d unknown
- Annual Rent

Maintenance/recurrent inputs and costs per unit per year

Inputs	Costs (US$)	% met by land user
Labour	590.30	100%
TOTAL	**590.30**	**100.00%**

Remarks:
The farmer already owns the land user certificate for the property and only has to pay annual taxes and the people who control the pasture. He covers these costs with the rent he gets for the grazing livestock.
Costs which concern the information transfer to the herders is not calculated, as it is done informally. Only guardening by the employed people is monetarised.

Assessment

Impacts of the Technology

Production and socio-economic benefits		Production and socio-economic disadvantages	
+++	increased water availability / quality	+	loss of land
+	increased farm income	+	hindered farm operations
+	decreased workload		

Socio-cultural benefits		Socio-cultural disadvantages
++	community institution strengthening	
++	improved conservation / erosion knowledge	
+	improved food security / self sufficiency	

Ecological benefits		Ecological disadvantages
++	reduced surface runoff	
++	improved soil cover	
++	reduced soil compaction	
+	increased soil moisture	
+	reduced hazard towards adverse events	
+	increased biomass above ground C	
+	increased soil organic matter / below ground C	
+	reduced soil loss	
+	reduced soil crusting / sealing	
+	increased / maintained habitat diversity	

Off-site benefits		Off-site disadvantages
+	reduced downstream flooding	

Contribution to human well-being / livelihoods

\+ The farmer possessing the user certificate of the land states that even poor families are allowed to graze their livestock for a low rent and thus this pasture management seems to lead to more equity among the farmers of different economic classes. The better the livestock is fed, the higher the value of livestock and the wealthier the households are. But this statement could not be verified and should be taken with precaution.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	positive	very positive
Maintenance / recurrent	positive	very positive

Establishment and maintenance cost are low. Input consists mainly of the establishment of a pasture management which is based on dissemination of knowledge and information

Acceptance / adoption:

There is no trend towards (growing) spontaneous adoption of the technology. Precondition is a big grazing land property, but only a small amount of farmers do own such a property.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
No high establishment and maintenance cost → Regular knowledge exchange and communication must take place between herders and certified land user	Precondition for such a setup is that one farmer owns the user certificates for a big grazing land, which is unusual. It is not clear how he got the user rights. → Ideally communal grazing land would be divided among several households sharing access to pastures
No high physical inputs required →	The pasture shows still a lot of signs of erosion and degraded areas. → Less livestock or division into more parts to allow the vegetation cover to rest for a longer time span. Enhance a homogeneous grazing of upper and more distant parts of the pasture. Control if pasture management is adhered consequently. Additional conservation measures such as resowing of specific areas, or fencing of badly degraded areas such as gullies.
Economic (better fodder quality) and ecological benefits (grass recovery, erosion reduction) can be seen as a direct result of pasture rotation → Further promotion of improved grazing schemes aiming at increasing grass productivity is needed. To re-establish tree cover and increase soil stability trees should be planted	This system works when there are communal pastures in the surrounding area. On the here documented pasture, less livestock is kept than on communal pastures. This lower density of livestock is not realistic at watersheds level, because it might raise the pressure on land in the other pastures. → Rotating within the grazing land just combats the fact that there is too much livestock compared to the available area
It is a good platform to share and spread knowledge of good practices, as over time many farmers come regularly to graze → Use that base of directly concerned farmers (to show how pasture or gullies regenerate etc)	It is not clear whether the main motivation of this private pasture is to stop degradation or to collect the renting fees → Elaborate an investment plan showing how the collected fees will be reinvested into grazing land infrastructure and how much is taken for reimbursing the efforts of the certified land user.
Equity amongst the farmers through flexible renting prices → A consistent price structure for different types of livestock owners that can be communicated to those interested in herding their animals in the area.	It is not known whether the different fee levels according to the herders provenance does not create discontentment → Transparent price structure
	Other cost intensive investments required like building another waterpipe and planting trees →

Current agroforestry: orchard with wheat intercropping

Tajikistan

left: Grazing cattle in the mulberry and apple orchards (Photo: Malgorzata Conder)
right: Wheat cropping between the tree rows (Photo: Malgorzata Conder)

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 0.01 km^2
Origin: Developed government, 10-50 years ago
Land use type:
Mixed: Agroforestry
Climate: subhumid, temperate
WOCAT database reference: T_TAJ049en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-08-01

Current agroforestry of a degraded mulberry and apple orchard with wheat intercropping

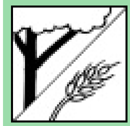
Since 1992 an area of around one ha has been owned by the farmer. He planted mulberry trees the same year. At that time, orchards were established in the whole surrounding area because the government decreed that a territory should have plenty of mulberry trees. Despite the government plan, all the land users of that area began to switch their orchards into wheat crops. Five years later the farmer planted apple trees within the mulberry orchard. The orchard had 200 mulberry and 100 apple trees. The motivation was to feed the working farmers of the fields around. Five years later the apple trees gave fruits. But only the first two years gave a good yield and income from selling them. Later on the fruits were just eaten by the farmer’s family. After another seven or eight years the farmer grew a wheat crop in between the tree lines. Nowadays it's the only remaining orchard in that area. Due to the lack of proper maintenance and water availability the orchard is degraded and the output is very low.
The government established a large territory of mulberry orchards, for three reasons: First to reduce the impact of natural hazards, second to increase silk production and last to improve fire wood availability. The planting of apple trees should be beneficial for farmers working in the surrounding crops and well as for the family, who sell the fruits and the mulberry leaves. As the yield started to decrease the wheat crop was established to have a bigger output for that crop.
Due to the government’s order to establish orchards, the local authorities provided the mulberry trees. Hence, it was in the responsibility of the farmer to plant the trees and to look after them by soil loosening and pruning. The latter activity must be done once in the first five years after planting. The farmer bought the apple trees himself as they were cheap at that time. To establish the wheat crop, ploughing, seeding, fertilizing and finally harvesting must be done. One person is supposed to guard the orchard and wheat crop every day. Yearly maintenance consists of soil loosening around the fruit trees and the above mentioned task for cropping. The maintenance of the orchard seems to be abandoned more and more, probably because the output decreases year by year.
The orchard is situated below Momandion village, on the very last foot slope before the valley plain begins and, hence, it has a slight slope,. In the past, orchards were numerous, but nowadays wheat crops have mostly replaced the orchard. As there is no fence and no one to control it regularly, livestock invades the property. During its first two years there was a water source, which had dried up by the time. The orchard is a relic being the only and last one in that area. Broken branches, unpruned trees and a trampled crop, show signs of insufficient control and maintenance and therefore of a gradual abandonment of the orchard.

Classification

Land use problems:

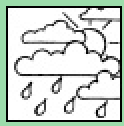
- Trampled and degraded soil as a consequence of no fences or control. Soil crusting and compaction because of lack in organic matter resulting in a low infiltration rate. (expert's point of view)
water scarcity and low soil moisture, small yield of the fruit trees (land user's point of view)

Land use



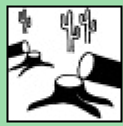
Agroforestry
rainfed

Climate



subhumid

Degradation



Biological degradation:
reduction of vegetation cover

Conservation measure

Stage of intervention

Prevention
Mitigation / Reduction
Rehabilitation

Origin

Land users initiative: 10-50 years ago
Experiments / Research
Externally introduced
Other: government: 10-50 years ago

Level of technical knowledge

Agricultural advisor
Land user

Main causes of land degradation:
Direct causes - Human induced: other human induced causes, monocropping, lack of maintenance

Main technical functions:
- improvement of ground cover
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- improvement of subsoil structure (hardpan)
- increase / maintain water stored in soil

Secondary technical functions:
- control of concentrated runoff: retain / trap
- control of concentrated runoff: impede / retard
- control of concentrated runoff: drain / divert
- increase of infiltration

Environment

Natural Environment

Average annual rainfall (mm)

> 4000 mm
3000-4000 mm
2000-3000 mm
1500-2000 mm
1000-1500 mm
750-1000 mm
500-750 mm
250-500 mm
< 250 mm

Altitude (m a.s.l.)

> 4000
3000-4000
2500-3000
2000-2500
1500-2000
1000-1500
500-1000
100-500
<100

Landform

plateau / plains
ridges
mountain slopes
hill slopes
footslopes
valley floors

Slope (%)

flat
gentle
moderate
rolling
hilly
steep
very steep

Soil depth (cm)

0-20
20-50
50-80
80-120
>120

Growing season(s): 180 days (April-Sept/Oct)
Soil texture: medium (loam)
Soil fertility: low
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: low
Availability of surface water: poor / none
Water quality: for agricultural use only
Biodiversity: low

Tolerant of climatic extremes: wind storms / dust storms
Sensitive to climatic extremes: seasonal rainfall increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods, droughts / dry spells, decreasing length of growing period
If sensitive, what modifications were made / are possible: Higher vegetation cover, which would make the land use more resistant to drought, more stable in case of floods and heavy rainfalls.

Human Environment

Mixed per household (ha)

<0.5
0.5-1
1-2
2-5
5-15
15-50
50-100
100-500
500-1,000
1,000-10,000
>10,000

Land user: employee (company, government), Small scale land users, common / average land users, mainly men
Population density: 50-100 persons/km2
Annual population growth: 2% - 3%
Land ownership: individual, titled
Land use rights: leased (Based on land user's Certificates)
Water use rights: individual (Based on land user's Certificates)
Relative level of wealth: average

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low: technical assistance, employment (eg off-farm), energy, financial services; moderate: health, education, market, roads & transport, drinking water and sanitation
Market orientation: subsistence (self-supply)

Implementation activities, inputs and costs

Establishment activities

- Buying, transport and planting of mulberry trees, 10 days (7 hours/day), 3 people
- Buying, transport and planting of apple trees, 5 days (7 hours/day), 3 people

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	497.40	100%
Agricultural		
- seedlings	311.00	33%
TOTAL	**808.40**	**74.22%**

Maintenance/recurrent activities

- Plowing vertically, 4 hours of labour, tractor and petrol
- Buying (200 kg) and sowing wheat, 2 hours, 3 persons
- Applying fertilizer, 2 hours, 1 person, 2 bucks à 50 kg
- Cutting wheat, 4-5 days (6 hours/ day), 4 people
- Guardening
- loosening around trees (ca. on 1/3 of the trees), 4-5 trees a day
- pruning (ca. 1/2 of mulberry trees), 7-8 days (2-3 hours/ day), 3 persons

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	572.20	100%
Equipment		
- machine use	24.80	100%
-	28.50	100%
Agricultural		
- seeds	82.80	100%
- fertilizer	76.60	100%
TOTAL	**784.90**	**100.00%**

Remarks:
Labour is the most important input, but as it is done mostly by the farmer or the family itself it's mainly agricultural material as seedlings, seeds and fertilizer. Latter particularly as recurrent costs.
The cost were calculated for 1 ha, but one have to consider that an orchard and wheat crop is on the same plot. This means that there's not fully a wheat crop of 1 ha. Mulberry seedling were paid by the government, apple trees by the farmer. Machine use and petrol, are all included in the labour input in the establishment phase, as it was not separately mentioned by the farmer.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+ decreased workload

Production and socio-economic disadvantages

++ decreased irrigation water availability / quality
++ increased demand for irrigation water
++ decreased farm income
+ reduced crop production

Socio-cultural benefits

Socio-cultural disadvantages

+ decreased food security self sufficiency

Ecological benefits

Ecological disadvantages

+ decreased water quantity
+ decreased soil moisture
+ decreased soil cover
+ decreased soil organic matter

Off-site benefits

Off-site disadvantages

++ decreased buffering / filtering capacity

Contribution to human well-being / livelihoods

Benefits /costs according to land user

	Benefits compared with costs	short-term:	long-term:
	Establishment	not specified	not specified
	Maintenance / recurrent	not specified	not specified

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
It is the only orchard in the neighbourhood, which is why it would be worthy to maintain it. → Put more effort and labour into the orchard, currently only the wheat crops seems to be of interest for the farmer.	Lack of maintenance and guarding or fencing. → More focus on the orchard as it has also ecological benefits. Enhance the farmer to put more labour into the orchard.
The orchard gave by-product as leaves for silk production and branches. →	Show good examples of orchards and their resulting benefits. Round tables by and for farmers to share experiences.
	Currently the orchard is too old to get a good yield and maintenance activities are comparatively high. →


left: Fodder grain crop (Photo: Malgorzata Conder)
right: Petrified clay conglomerate as indicator for soil degradation (Photo: Malgorzata Conder)

Current feed grain cultivation
Tajikistan

Cultivation of wheat or feed grain for straw production on a degraded plot

The farmer started to plant flax for oil production on his 0.2 hectare plot, which gave a good harvest. Since 1999 the farmer has cultivated wheat and feed grain, rotating year by year. According to the farmer, wheat and feed grain cropping does not provide a benefit on that plot, when money and labour inputs are considered. But as straw is scarce but is needed for his cows, the farmer gets that by-product from harvesting wheat. Furthermore, as that plot is accessible by the tractor for ploughing, he plants wheat and will continue doing that in future, even though the output is low. Though the farmer has a land user's certificate for that property, it becomes common for livestock grazing after the harvest. This causes overgrazing, bare soil, trampling and other issues. The purpose of cropping wheat is to get straw for feeding. According to the farmer the bad quality of soil and the absence of water do not allow a different crop type than wheat.
Establishment and maintenance activities are almost the same. The crop must be ploughed, seeds planted and fertilizer applied. Though no fertilizer was needed at the beginning of crop cultivation, now its use is increasing. Between the time of planting and harvesting, the crop is regularly safe guarded from grazing livestock. If herds approach, the farmer or a family member will protect the crop. After the harvest, the crop is somehow declared as communal land, where cattle are allowed to graze there.
The crop is situated on a ridge above the village of Chargii bolo. It is a small sized terrace with a slight slope. Soil quality and moisture were already very poor when the crop was established, which results in a low output comparing to the input. The soil is compacted and shows a low level of organic matter, soil moisture and nutrients. The farmer complains about the small sharp stones of around 1-2 cm of diameter in the soil. They indicate a high level of soil degradation. Although the slope is slight, the vertical ploughing has caused small rills in the lower part of the plot and some more pronounced rills off-site. The plot is the property of the farmer, but is used as pasture after harvest for the livestock. Soil compaction, lowered vegetation cover and water infiltration result from trampling and overgrazing. There's no agreement between cultivars and herders, reason why this crop continues to be grazed uncontrolled.

Location: Khatlon, Tajikistan
Region: Muminobod
Technology area: 0.002 km^2
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed through land user`s initiative, 10-50 years ago
Land use type:
Cropland: Annual cropping
Climate: subhumid, temperate
WOCAT database reference: T_TAJ050en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-08-10

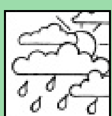
Classification

Land use problems:
- Low soil nutrients and moisture on that plot. Bare and crusted soil which cause worse infiltration capacities and soil erosion. Building of small rills enhanced through vertical ploughing. Additionally, overgrazing by livestock, compaction of soil. (expert's point of view)
Crop was already degraded at the beginning but its getting worse. Small and sharp stones which are in the soil indicate the compaction and low level of nutrients. (land user's point of view)

Land use

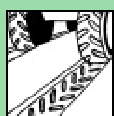
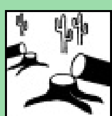
Annual cropping rainfed

Climate



subhumid

Degradation

Physical soil deterioration: compaction, Biological degradation: reduction of vegetation cover

Conservation measure

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: 10-50 years ago
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: soil management
Indirect causes: land tenure

Main technical functions:

Secondary technical functions:

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 180 days (April-Sept/Oct)
Soil texture: medium (loam)
Soil fertility: high
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: very low
Availability of surface water: poor / none
Water quality: for agricultural use only
Biodiversity: low

Sensitive to climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods, droughts / dry spells

Human Environment

Cropland per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: individual, titled
Land use rights: leased
Water use rights: communal (organised)
Relative level of wealth: average

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low: technical assistance, employment (eg off-farm), energy, drinking water and sanitation, financial services; moderate: health, education, market, roads & transport
Market orientation: subsistence (self-supply)
Mechanization: mechanised
Livestock grazing on cropland: yes

Implementation activities, inputs and costs

Establishment activities

Maintenance/recurrent activities

- Plowing, 11 hours, 1 person
- Sowing wheat, 10-12 hours, 3 persons
- Applying fertilizer, 10 hours, 1 person
- Cutting wheat, 4-5 days, 3 persons
- Guarding, 1 person

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	1265.50	100%
Equipment		
- machine use	42.00	100%
- petrol	80.00	100%
Agricultural		
- seeds	62.00	100%
- fertilizer	45.30	100%
TOTAL	**1494.80**	**100.00%**

Remarks:
Agricultural inputs as seeds and fertilizer are the most expensive
Labour, machine use and petrol was indicated for totally 0.8 ha, this is why all input is divided by 4 for the compilation of reccurent activities for the plot of 0.2 ha. The input were further multiplied by factor 5 for the cost overview for one ha.

Assessment

Impacts of the Technology

Production and socio-economic benefits

Production and socio-economic disadvantages

++ decreased irrigation water availability / quality
+ reduced crop production
+ increased expenses on agricultural inputs

Socio-cultural benefits

Socio-cultural disadvantages

++ decreased food security self sufficiency

Ecological benefits

Ecological disadvantages

++ decreased soil moisture
++ increased surface water runoff
++ decreased soil cover
++ increased soil erosion locally
+ decreased water quantity
+ decreased soil organic matter
+ increased soil sealing / compaction

Off-site benefits

Off-site disadvantages

++ decreased buffering / filtering capacity
+ increased damage on neighbours fields

Contribution to human well-being / livelihoods

Benefits /costs according to land user

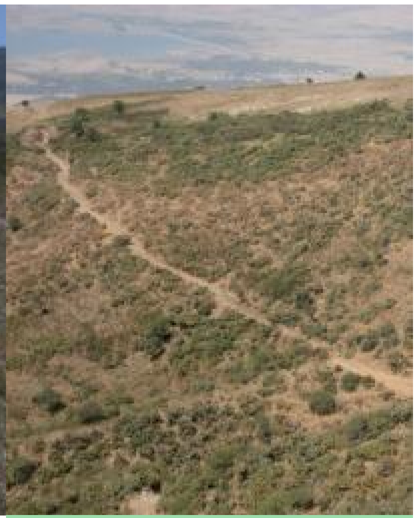
Benefits compared with costs	short-term:	long-term:
Establishment	not specified	not specified
Maintenance / recurrent	not specified	not specified

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Suitable cropland for wheat production as it is accessible by tractor and shows a small inclination. →	Soil erosion, high run off rate, low infiltration capacity, low soil moisture. → Countour tillage, crop rotation, double digging or breaking of compacted subsoil. Knowledge transfer for showing alternatives to wheat and fodder grain cropping (crop rotation).
	Uncontrolled grazing after the harvest reduces vegetation cover to hardly no cover, which makes soil very exposed to soil erosion etc. → Regulate and coordinate grazing.

WOCAT



Pasture management of a communal grazing land

Tajikistan

Pasture management of a communal land through daily rotation

The total area of the pasture accounts for 300 – 500 ha. The pasture is property of the Doshmand village but it includes also some private properties, mainly potato and wheat crops. After the harvest, livestock is also grazing on these crops. Eighteen households are currently using the pasture with a total of 150 cows and 500 small animals. Additionally, three groups of herds from other villages graze irregularly on this pasture mainly on the lateral parts as it is less guarded by the villagers. The interviewee estimates that over 1000 cows, goats and sheep are coming from other villages. Other herds cross this pasture when migrating to or coming back from the summer pasture in spring and autumn, respectively. Nevertheless Doshmand residents claim that this intrusive grazing is accepted as “every animal has to be fed”. This shows the need of a pasture management not only on village but also on watershed level. During Soviet time the inhabitants of Doshmand were forced to migrate to the valley. In 2003, the resettlement of the ancient location started with two families. Simultaneously, the pasture management was established and joined by each family who resettled. The controlled area is divided in 4 subparts. The herd switches daily within them. Every household looks after the herd for a day, which results in a rotational cycle of 18 days. There are no fixed and regular meetings for pasture management within the village pasture. However, two subsequent herders communicate to know where the herd has been grazing and where to graze the next time.
Purpose of the rotational grazing is to graze on one subpart, while the three other areas are resting. This reduces the impact of grazed and trampled areas per subpart and allows the growth and recovery of the vegetation in the other parts. The task of herding is shared among the families. The rotational grazing is organized orally and freely, why it’s not sure if that approach is strictly binding. Discussions about pasture management rise only in case of need.
Doshmand village got the pasture in a good condition at the time of establishment. Vegetation cover was high. The only investment consisted in building a water point for the livestock. A further investment was to buy a water pipe and dig out a channel for the pipe to conduct the water from the water point to the village. Money was collected by the families and many villagers were involved in digging the channel. No further input was and is required except coordination between the herders.
The pasture of Doshmand village is located in the middle and upper zone of the watershed. Thanks to the distance to other settlements, the pasture is less affected by overgrazing than other communal pastures in the watershed. Nevertheless, the pasture is heterogeneously grazed, with some areas which are difficult to access even for livestock and hence abundant vegetation. Other areas, especially those situated next to the village show a more bare vegetation cover.

left: Eroded path through the pastureland (Photo: Malgorzata Conder)
right: Heterogenous vegetation cover within the watershed (Photo: Malgorzata Conder)

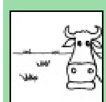
Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 4 km^2
Conservation measure: management
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed through land user`s initiative, 10-50 years ago
Land use type:
Grazing land: Extensive grazing land
Climate: subhumid, temperate
WOCAT database reference: T_TAJ051en
Related approach: Common village herding (A_TAJ007en), Livestock Commitee at Village Level (A_TAJ013en)
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-09-25
Contact person: Sa'dy Odinashoev, Caritas Switzerland, Muminabad, Tajikistan

Classification

Land use problems:

- Erosion Overgrazing (expert's point of view)
increase of unpalatable vegetation (land user's point of view)

Land use

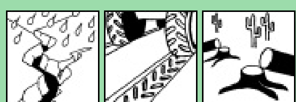


Extensive grazing land
extensive grazing land
rainfed

Climate

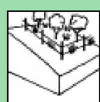
subhumid

Degradation



Soil erosion by water: offsite degradation effects, Physical soil deterioration: compaction, Biological degradation: reduction of vegetation cover

Conservation measure



management: Change of management / intensity level

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: 10-50 years ago
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: overgrazing
Indirect causes: land tenure

Main technical functions:
- improvement of ground cover
- increase of infiltration

Secondary technical functions:
- improvement of topsoil structure (compaction)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 160 days (April-Sept)
Soil texture: medium (loam)
Soil fertility: low
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: medium

Soil water storage capacity: medium
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: poor drinking water, for agricultural use only
Biodiversity: high

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, wind storms / dust storms
Sensitive to climatic extremes: seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods, droughts / dry spells
If sensitive, what modifications were made / are possible: Conduct the rotational grazing even more strictly

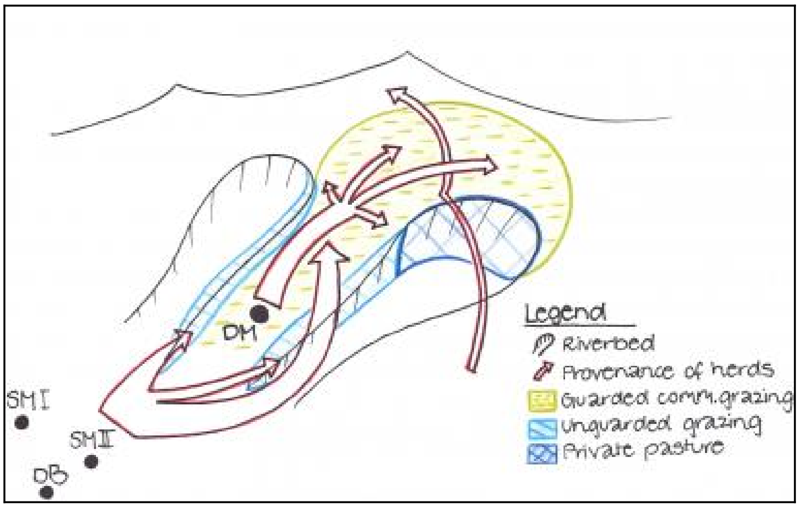
Human Environment

Grazing land per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: groups / community, Small scale land users, common / average land users, men and women
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: state
Land use rights: leased (Land ownership is based on the land user certificate conferred by the government)
Water use rights: communal (organised) (Land ownership is based on the land user certificate conferred by the government)
Relative level of wealth: average

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low: technical assistance, employment (eg off-farm), market, energy, roads & transport, financial services; moderate: health, education, drinking water and sanitation
Market orientation: subsistence (self-supply)
Livestock density: > 100 LU /km2



Technical drawing

Livestock from Doshmand village (DM) is grazing in the four subparts of the communal pasture. Livestock from other villages, located in the valley Sarmadoni I (SMI) and II (SMII) and Dehibaland (DB), can invade the guarded and unguarded communal pasture of Doschmand. In spring and autumn also other livestock crosses Doshmand's pasture when migrating to or leaving the summer pasture. (Malgorzata Conder)

Implementation activities, inputs and costs

Establishment activities

- Coordination with villagers and herders

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	0.00	0%
TOTAL	**0.00**	**0.00%**

Maintenance/recurrent activities

- Consultation with village herders

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	0.00	0%
TOTAL	**0.00**	**0.00%**

Remarks:
There are no costly factors, the most important input is a good planning, coordination and consistent execution of the rotational grazing system. The installation of a waterpoint would be needed but it is a very costly installation.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+ increased fodder production

Production and socio-economic disadvantages

Socio-cultural benefits

+ community institution strengthening
+ improved food security / self sufficiency

Socio-cultural disadvantages

Ecological benefits

++ reduced surface runoff
++ reduced hazard towards adverse events
+ increased soil moisture
+ reduced evaporation
+ increased biomass above ground C
+ reduced soil crusting / sealing
+ reduced soil compaction

Ecological disadvantages

Off-site benefits

+ reduced downstream siltation
+ improved buffering / filtering capacity

Off-site disadvantages

Contribution to human well-being / livelihoods

++ Strenghtening of the community sense and awareness through increased coordination for rotational grazing between villagers. Higher fodder availability leads to healthier livestock.

Benefits /costs according to land user			
	Benefits compared with costs	**short-term:**	**long-term:**
	Establishment	neutral / balanced	slightly positive
	Maintenance / recurrent	neutral / balanced	positive

Acceptance / adoption:

There is little trend towards (growing) spontaneous adoption of the technology. Effort is made to introduce more rotational grazing on cummunity level in the region with institutional support.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
In a rotational grazing system at village level every family is responsible for the sustainability of the pasture → Give more responsability and co-determination to individuals	In reality, rotational grazing is not executed strictly enough → Stricter separation of the subparts needed
High establishment potential as rotational grazing do not demand any costs, except coordination and organization on village level → Disseminate the idea of rotational grazing also on watershed level	Herds from other villages graze in the same pasture → Strenghten coordination of grazing between and within villages
Ecologic benefits as high vegetation cover, less erosion etc. can be achieved without monetary investment → Spread knowledge of long-term effects by rotational grazing	Some flanks show high vegetation because they are not accessible for livestock and not because of the rotational grazing →
Being a pasture of a big area extent in the uphills, the good quality of the pasture plays an important role for all the settlements and cultivations downstream → Raise the awareness about the upstream-downstream interrelation in the watersheds	
No big input, coordination between farmers exists anyway →	

Current agroforesty of an apple orchard with wheat cropping

Tajikistan

left: Grazing cow in between the unfenced apple orchard (Photo: Malgorzata Conder)
right: Old and abandoned apricot orchard (Photo: Malgorzata Conder)

Agroforestry of an old apple orchard with wheat cropping

The farmer grows red, yellow and white apples in his orchard of 3.75 ha. Wheat is growing in the slightly pronounced terraces and recently some vines were planted this year. The rain fed orchard lies in the low part of the middle zone and has a slight slope. The absence of control and fence results in broken branches and trampled parts in the plot. The farmer is sharing the property with his four brothers, who inherited the property from their father in 1993 or 1994. The orchard was established during Soviet time in 1988. The government paid for the material and the farmer's family did the labour. The government paid them for that input by crop yield. In addition to the orchard the farmer sewed wheat between the rows several years ago which adds up to a hectare of wheat crop in total. In the current year (2012), the workload and the yield have been very small. As there was heavy rainfall in spring, the farmer did not see the need to loose soil around the trees. The already old fruit trees gave low yield and, because of a hale storm, apples were destroyed.
Initially the government planned to manage land and make it more profitable by establishing orchards. Due to that intention the farmer's family had work, subsistent crop and cash crops. Today the main source of income is the remittances from the sons who work in Russia. The farmer works part time as a taxi driver. The orchard lost its importance of main income.
At the time of the establishment of the fruit trees, the Soviet government paid for the seedlings and tractor fuel. Labour was done by the farmer, his brothers and their parents. The whole family worked for two years to build the orchard because they only had the possibility to work in the evenings and on weekends. Nowadays it is still a part time job for the farmer. Maintenance activities consist of ploughing, occasional soil loosening around the trees, pruning and harvesting apples and wheat. The wheat is cut by hand, which is very hard work. Because of heavy rainfalls last spring no soil was loosened. There is nobody to protect the orchard from grazing livestock.
The orchard lies on a foothill in the middle zone, close to the settlements of the valley. The apples trees are growing in rows on small terraces built by ploughing for years. Down- and upwards there are also orchards growing, all delimited laterally by the riverbed and a road. On one side of the plot a gully is developing rapidly. All of the neighbouring orchards seem to have a lack of maintenance and control. The orchards lying above but not far away from the settlements are accessible by car and tractor.

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 3.75 km^2
Origin: Developed externally / introduced through project, 10-50 years ago
Land use type:
Mixed: Agroforestry
Climate: subhumid, temperate
WOCAT database reference: T_TAJ052en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-08-20

Classification

Land use problems:

- Low soil nutrients and moisture A lot of bare, compacted and trampled soil which impedes a high infiltration rate Not sufficiently maintained orchard, incorrectly prouned fruit trees Deep rill through the middle of the plot (expert's point of view) Soil is leached out Fruit trees are old and hence don't give a high yield Water is only seasonally available Low infiltration (land user's point of view)

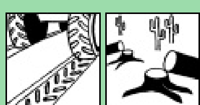
Land use

Agroforestry
rainfed

Climate

subhumid

Degradation



Physical soil deterioration: compaction, Biological degradation: reduction of vegetation cover

Conservation measure

Stage of intervention

- [ ] Prevention
- [ ] Mitigation / Reduction
- [ ] Rehabilitation

Origin

- [ ] Land users initiative
- [ ] Experiments / Research
- [x] Externally introduced: 10-50 years ago

Level of technical knowledge

- [x] Agricultural advisor
- [x] Land user

Main causes of land degradation:
Direct causes - Human induced: soil management, crop management (annual, perennial, tree/shrub)

Main technical functions:

Secondary technical functions:

Environment

Natural Environment

Average annual rainfall (mm)

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

Altitude (m a.s.l.)

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

Landform

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

Slope (%)

- [ ] flat
- [ ] gentle
- [ ] moderate
- [x] rolling
- [ ] hilly
- [ ] steep
- [ ] very steep

Soil depth (cm)

- [ ] 0-20
- [x] 20-50
- [ ] 50-80
- [ ] 80-120
- [ ] >120

Growing season(s): 180 days (March to September)
Soil texture: medium (loam)
Soil fertility: low
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: low
Availability of surface water: poor / none
Water quality: for agricultural use only
Biodiversity: low

Sensitive to climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods, droughts / dry spells, decreasing length of growing period

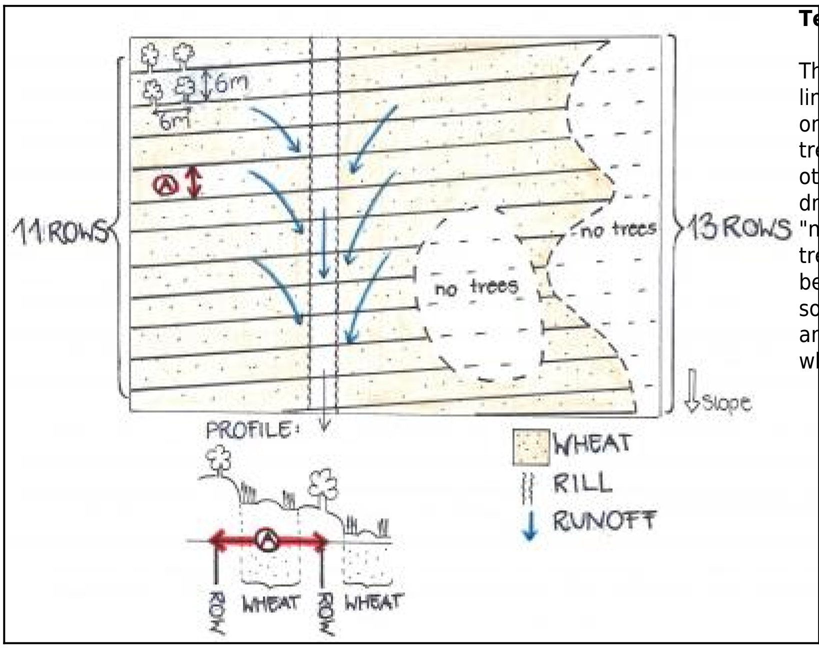
Human Environment

Mixed per household (ha)

- [ ] <0.5
- [ ] 0.5-1
- [ ] 1-2
- [x] 2-5
- [ ] 5-15
- [ ] 15-50
- [ ] 50-100
- [ ] 100-500
- [ ] 500-1,000
- [ ] 1,000-10,000
- [ ] >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: individual, titled
Land use rights: leased
Water use rights: communal (organised)
Relative level of wealth: average

Importance of off-farm income: > 50% of all income: The farmer is working mainly as taxi driver
Access to service and infrastructure: low: technical assistance, employment (eg off-farm), energy, financial services; moderate: health, education, market, roads & transport, drinking water and sanitation
Market orientation: subsistence (self-supply)



Technical drawing

The rows with the apple trees are not contour lined, reason why the plot counts 11 rows from one and 13 rows from the other side. The fruit trees grow with a distance of 6 metres to each other. Up to 30 trees were in a row, but due to drying or cutting out (shown in the drawing as "no trees") there are currently some 20 to 25 trees per row in average. Wheat is growing between the rows, mechanical plowing built some terrace-like relief as seen in the profile and sequency "A". A rill dominates the orchard where run off is drained. (Conder Malgorzata)

Implementation activities, inputs and costs

Establishment activities

- Buying, transporting and planting trees (5 TJS and 20 min for plantin per tree)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	165.60	100%
Equipment		
- machine use	4.40	0%
Agricultural		
- seedlings	331.30	0%
TOTAL	**501.30**	**94.32%**

Maintenance/recurrent activities

- Plowing, 6 hours, 1 person
- Sowing, 3 hours, 1 person
- Cutting wheat manually by, 1 week (7h/day) 6 pers
- Soil loosening (it was not done in 2012)
- Pruning (it was not done in 2012)
- Harvesting apples (1000)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	324.15	100%
Equipment		
- machine use	5.52	100%
-	12.10	100%
Agricultural		
- seeds	22.08	100%
TOTAL	**363.85**	**100.00%**

Remarks:
Labour affects the cost the most, secondly the seedlings (which were subsidised).
Establishment phase: Seedlings and transport were paid by the government, planting was done by the farmer and his family.
Labor (recurrent activity(3))for apple harvesting calculated according to T_TAJ013.

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages
+ decreased workload	++ decreased farm income + reduced crop production

Socio-cultural benefits	Socio-cultural disadvantages
	+ decreased food security self sufficiency

Ecological benefits	Ecological disadvantages
	++ decreased soil cover ++ increased soil sealing / compaction + decreased soil moisture + increased surface water runoff + decreased soil organic matter + increased soil erosion locally

Off-site benefits	Off-site disadvantages
	+ increased downstream flooding + decreased buffering / filtering capacity

Contribution to human well-being / livelihoods

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	not specified	not specified
Maintenance / recurrent	not specified	not specified

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Land management is right if maintenance and technical assistence are warranted. → Support of establishment and recurrent activities is important.	Orchard is not well maintained (sporadical soil loosening, pruning, control). → Knowledge transfer with e.g. demonstration of well maintained orchards and round tables to share farming experiences.
Increase of productivity of the land by establishing an orchard. → Give more power and knowledge to farmers to raise responsability for the crops.	Support shoulb not only focus on the establishment phase (by provdiding funds) but also in a long-term providing cultivation knowledge.
	Old trees. → Plant new ones.

left: Contour plowed wheat crop after harvest (Photo: Malgorzata Conder)
right: Rill building on the wheat crop (Photo: Malgorzata Conder)

Current wheat crop in rotation with chickpea cultivation

Tajikistan

Current wheat crop in yearly rotation with chickpea cultivation

The rainfed crop of the farmer sizes around a hectare. He owns the crop since seven years and switches between chickpea and wheat every year. When he started to cultivate, soil properties were good, he did not use fertilizer. Because of the years of ploughing, the soil lost nutrients and moisture. The more rill building and slope instability is severe currently. The plot is over one hectare because it includes a narrow vegetation strip between his and the neighbours crop. The plot, as all the other crops are grazed by livestock, after harvest.
Chickpea cropping generates a satisfactory yield, whereas wheat production is rather variable and low. Nevertheless the farmer would not change the crop type because the main purpose is to get straw for feeding his cows. The farmer has over three hectares in total. Even though he claims the benefit to be low comparing to the input, he is content as long he can feed his family.
Ploughing, sowing and then harvesting were part of the establishment phase. The same activities count for maintenance. But as soil is gradually washed away, fertilizing became crucial. The farmer does not control and protect the crop from wild animals and grazing herds.
The crop lies on a foot slope not far from the riverbed. Neighbouring cultivations are of the same crop type, chickpea, wheat and food grain. It is less than one kilometre away from the farmers home in Doshmand village. Access to services is rather low, especially in winter, because of the bad condition of the road. Doctor, middle and higher school grades and market are in the village below.

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 0.01 km^2
Stage of intervention: rehabilitation / reclamation of denuded land
Land use type:
Cropland: Annual cropping
Climate: subhumid, temperate
WOCAT database reference: T_TAJ053en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-09-06

Classification

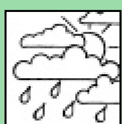
Land use problems:

- Sealed and compacted topsoil, which hinders infiltration. Hardpan is propable due to plowing. Erosive processes with rill building are relatively widespread on the crop. A lot of plowing rills aggrandize by runoff. A lot of licorish plant grow on the crop, which is a indicator for degraded soil. Soil shows a low level of organic matter, nutrients and moisture. (expert's point of view)
Increasing soil wash out with simultaneos augmentation of fertilizer input over years. Rills destroy crop growth, reason why yield quantity and quality is decreasing. (land user's point of view)

Land use

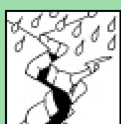
Annual cropping
rainfed

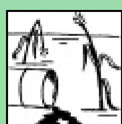
Climate



subhumid

Degradation





Soil erosion by water: loss of topsoil / surface erosion, gully erosion / gullying, Chemical soil deterioration: fertility decline and reduced organic matter content

Conservation measure

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: soil management, crop management (annual, perennial, tree/shrub)
Indirect causes: land tenure

Main technical functions:
- control of concentrated runoff: drain / divert
- improvement of surface structure (crusting, sealing)
- stabilisation of soil (eg by tree roots against land slides)
- increase in organic matter
- increase of infiltration

Secondary technical functions:
- control of concentrated runoff: impede / retard
- improvement of ground cover
- increase of surface roughness
- improvement of topsoil structure (compaction)
- improvement of subsoil structure (hardpan)
- increase in nutrient availability (supply, recycling,...)
- increase / maintain water stored in soil

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 180 days (March to September)
Soil texture: medium (loam)
Soil fertility: low
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: low
Water quality: for agricultural use only
Biodiversity: low

Sensitive to climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods, droughts / dry spells
If sensitive, what modifications were made / are possible: The crop would be less sensitive to heavy (seasonal) rainfalls or droughts if vegetation cover or mulching would be improved.

Human Environment

Cropland per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: individual, titled
Land use rights: leased (Land ownership is based on the Land user's certificate)
Water use rights: communal (organised) (Land ownership is based on the Land user's certificate)
Relative level of wealth: average

Importance of off-farm income: less than 10% of all income: The farmer has in total over 3 ha of crop. The output of straw of this one hectare makes 40% of his total income.
Access to service and infrastructure: low: technical assistance, employment (eg off-farm), market, energy, roads & transport, financial services; moderate: health, education, drinking water and sanitation
Market orientation: subsistence (self-supply)
Mechanization: manual labour, mechanised
Livestock grazing on cropland: yes

Implementation activities, inputs and costs

Establishment activities

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	232.10	100%
Equipment		
- machine use	20.70	100%
- petrol	45.50	100%
Agricultural		
- seeds	62.10	100%
TOTAL	**360.40**	**100.00%**

Maintenance/recurrent activities

- Plowing, 3.5 hours, 1 person
- Sowing wheat, 1 hour, 2 persons
- Applying fertilizer (not in the first year), 1 hour, 2 persons
- Cutting wheat, 6 days (à 8 hours), 3 persons

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	235.20	100%
Equipment		
- machine use	20.70	100%
- petrol	45.50	100%
Agricultural		
- seeds	62.10	100%
- fertilizer	62.10	100%
TOTAL	**425.60**	**100.00%**

Remarks:
Establishment and maintenance cost are similar. Agricultural inputs as seeds and fertilizer are the highest expenditures. As soil nutrients are washed out, the fertilizer input rises gradually.

Assessment

Impacts of the Technology

Production and socio-economic benefits

Production and socio-economic disadvantages

- + reduced crop production
- + increased risk of crop failure
- + increased expenses on agricultural inputs
- + decreased farm income

Socio-cultural benefits

Socio-cultural disadvantages

- + decreased food security self sufficiency

Ecological benefits

Ecological disadvantages

- ++ increased surface water runoff
- ++ increased soil erosion locally
- + decreased soil moisture
- + decreased soil cover
- + decreased soil organic matter
- + increased soil sealing / compaction
- + reduced biodiversity / crop diversity

Off-site benefits

Off-site disadvantages

- + increased downstream flooding

Contribution to human well-being / livelihoods

Benefits /costs according to land user

	Benefits compared with costs	short-term:	long-term:
	Establishment	not specified	not specified
	Maintenance / recurrent	not specified	not specified

Farmer knows that there is no real benefit when looking at the input. Over the years it got slightly negative because more fertilizer is needed and yield is decreasing.

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Vegetation strip underneath the crop is an idea to develop as it reduces the negative offsite effects. → Knowledge transfer about how to reduce offsite effects. Soil cover could rise in that strip, thanks do what soil erosion woul be stopped. Enhance communication between above and below vegetation strip cultivating farmers.	Too much soil erosion causes rills. → Another crop type according to the steepness of the plot. Change plowing deepness or do human-powered tillage.
Maintain and develop crop rotation. → Knowledge transfer and field studies on other plots with crop rotation (e.g. perennial crops).	Development of soil crust, sealing and hardpan. → Enhance crop rotation and "soft" and horizontal tillage practices.
Plowing horizontally. →	Observed trampling and grazing of the plot. → Guarding or fencing of the plot. Guarding could be organized by several farmers in rotation.
	Poor pecentage of organic matter. → Introduce mulching.

Crop rotation including annual crops and Esparcet cultivation
Tajikistan

left: Esparcet plot situated on the mountain slope (Photo: Malgorzata Conder)
right: Growing Esparcet (Photo: Malgorzata Conder)

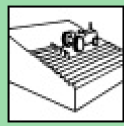
Crop rotation with current Esparcet production

An Esparcet plot of one hectare is located on a hillslope in the Chukurak watershed. The owner lives in the valley far away from the plot. During the harvest, he is staying in the hills a whole week, because a daily journey to his house would take too much time. For the last three years, the farmer is cultivating Esparcet with the main aim to feed his cows. In two years, he will switch to a wheat or chickpea plot. In total, the farmer owns19 hectares of cropland, out of which the Esparcet plot accounts for 20% of his income. Next to the Esparcet plot, other farmers cultivate wheat and chickpea. In contrast to Esparcet, those plots must be protected from boars. Even though irrigation is impossible and the water point is situated far away, Esparcet grows very well because of the straight and spread-out roots. Esparcet is beneficial for the state of soil fertility and soil stabilization. Their seeds are more expensive than wheat seeds, but also result in a higher harvest. Esparcet can be harvested up to three times a year depending on water availability.
The main purpose of Esparcet cultivation is fodder production for the cows. The farmer owns other plots where he cultivates wheat. Moreover, it’s a good location for an Esparcet plot: Even though water is not available Esparcet maintains the soil moisture and nutrients while reducing soil erosion. Thanks to the crop rotation, the soil is in a healthy state. Yield quantity and quality are very satisfying for the farmer.
The farmer stresses that good knowledge is needed to know where, what and how to cultivate. He learned from other farmers. Before establishing the perennial crop, he first planted a nurse crop of fodder grain in spring. Nurse crops strengthen soil stability while minimizing weed and overly sunlight. Plowing, sowing and cutting are initial as well as recurrent activities. No fertilizer and no plot guarding are needed. Initial costs when growing Esparcet are higher than for wheat, because Esparcet seeds are more expensive. Additionally, seeds of the nurse crop are needed. Not to neglect is the long way from the farmers’ house to the plot which takes time and fuel, but the farmers of that hillslope often give a lift to each other. Also during harvest the neighboring farmers are helping out.
The plot on the hillslope is located far away from the farmer’s’ village Sarmaydon 2. It’s situated at around 2000m asl below the hill peaks, where boars are entering. On three sides, the plot is delimited naturally by incised riverbeds which make accessibility more difficult. Due to the high altitude, there are low temperatures and high moisture. Above the Esparcet cultivation, wheat and chickpea plots are cultivated leading to off-site effects on the Esparcet plot. In the Esparcet plot, a deep rill developed originating from the wheat plot situated upslope.

Location: Khatlon, Tajikistan
Region: Muminabad
Technology area: 0.01 km^2
Conservation measure: agronomic
Stage of intervention: prevention of land degradation
Origin: Developed through land user`s initiative, recent (<10 years ago)
Land use type:
Cropland: Annual cropping
Grazing land: Intensive grazing/ fodder production
Climate: subhumid, temperate
WOCAT database reference: T_TAJ054en
Related approach:
Compiled by: Malgorzata Conder, CDE Centre for Development and Environment
Date: 2012-09-11
Contact person: Sa'dy Odinashoev, Caritas Switzerland, Muminabad, Tajikistan

Classification

Land use problems:
- The Esparcet plot is quite beneficial for soil and water properties. It is hence a good initial cultivation for future crop types. Soil stability is crucial as the plot is delimited by a riverbed on both sides. A wheat plot is located just above the Esparcet production. A rill developed in the upper plot, so that off-site effects like rill formation and sediment deposition are affecting the Esparcet plot. (expert's point of view)
Esparcet is maintaining soil stability and moisture which prevents major degradation. Several km2 got affected by washed soil form the upper part. No irrigation is possible. (land user's point of view)

Land use	Climate	Degradation	Conservation measure
			
Annual cropping Intensive grazing/ fodder production rainfed	subhumid	Soil erosion by water: loss of topsoil / surface erosion, offsite degradation effects	agronomic: Vegetation/soil cover agronomic: Organic matter / soil fertility

Stage of intervention

■ Prevention
□ Mitigation / Reduction
□ Rehabilitation

Origin

■ Land users initiative: recent (<10 years ago)
□ Experiments / Research
□ Externally introduced

Level of technical knowledge

□ Agricultural advisor
□ Land user

Main causes of land degradation:
Direct causes - Human induced: crop management (annual, perennial, tree/shrub)
Indirect causes: inputs and infrastructure

Main technical functions:
- control of concentrated runoff: retain / trap
- control of concentrated runoff: impede / retard
- control of concentrated runoff: drain / divert
- improvement of ground cover
- improvement of topsoil structure (compaction)
- stabilisation of soil (eg by tree roots against land slides)
- increase / maintain water stored in soil

Secondary technical functions:
- increase of surface roughness
- improvement of surface structure (crusting, sealing)
- improvement of subsoil structure (hardpan)
- increase in organic matter
- increase in nutrient availability (supply, recycling,...)
- increase of infiltration

Environment

Natural Environment

Average annual rainfall (mm)

□ > 4000 mm
□ 3000-4000 mm
□ 2000-3000 mm
□ 1500-2000 mm
■ 1000-1500 mm
□ 750-1000 mm
□ 500-750 mm
□ 250-500 mm
□ < 250 mm

Altitude (m a.s.l.)

□ > 4000
□ 3000-4000
□ 2500-3000
■ 2000-2500
□ 1500-2000
□ 1000-1500
□ 500-1000
□ 100-500
□ <100

Landform

□ plateau / plains
□ ridges
□ mountain slopes
■ hill slopes
□ footslopes
□ valley floors

Slope (%)

□ flat
□ gentle
□ moderate
□ rolling
■ hilly
□ steep
□ very steep

Soil depth (cm)

□ 0-20
□ 20-50
■ 50-80
□ 80-120
□ >120

Growing season(s): 160 days (April-Sept)
Soil texture: medium (loam)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: medium

Ground water table: < 5 m
Availability of surface water: medium
Water quality: for agricultural use only
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, droughts / dry spells
Sensitive to climatic extremes: heavy rainfall events (intensities and amount)
If sensitive, what modifications were made / are possible: High vegetation cover, improvement through more uniform sowing. Sowing manually causes an irregular soil cover and might be less tolerant to heavy rainfalls and drought.

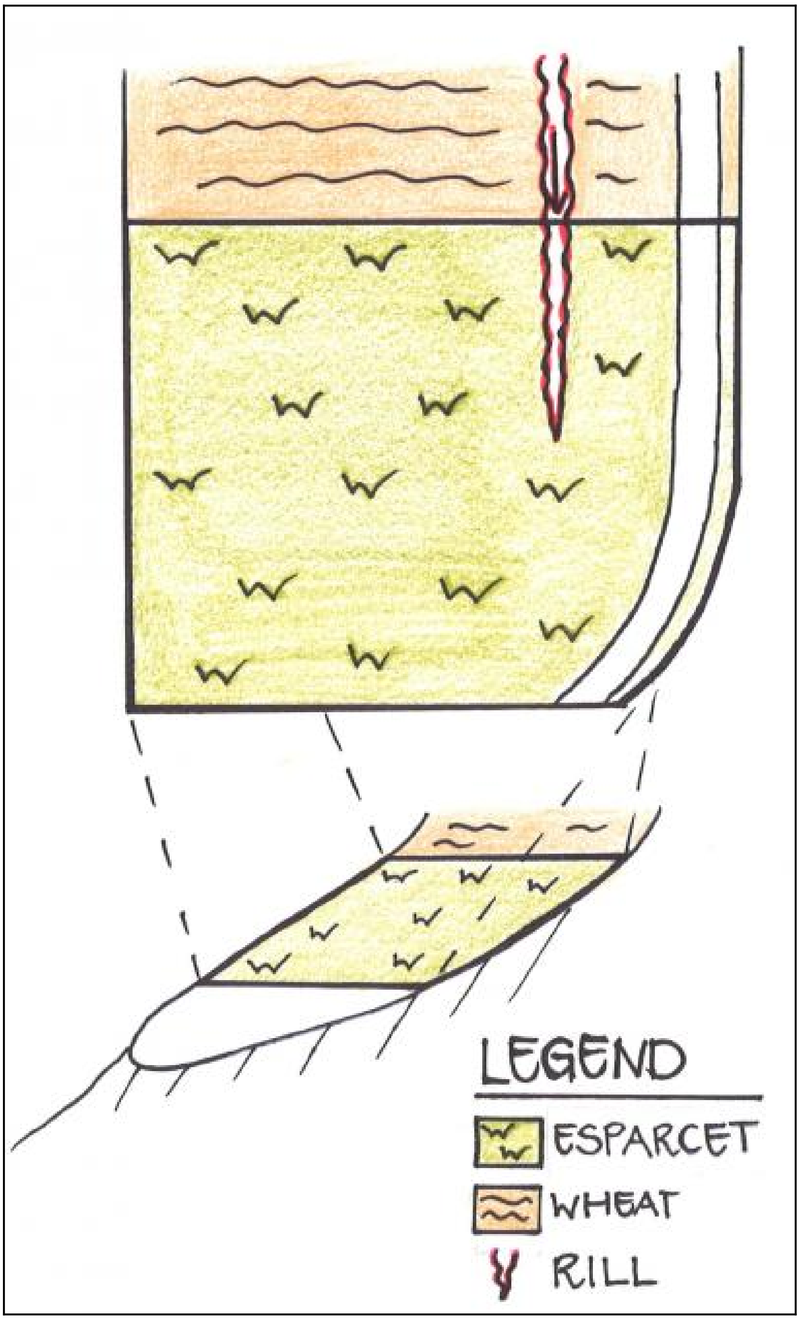
Human Environment

Cropland per household (ha)

□ <0.5
□ 0.5-1
□ 1-2
■ 2-5
□ 5-15
□ 15-50
□ 50-100
□ 100-500
□ 500-1,000
□ 1,000-10,000
□ >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 100-200 persons/km2
Annual population growth: 1% - 2%
Land ownership: state
Land use rights: leased (Land ownership is based on the land user certificate conferred by the government)
Water use rights: communal (organised) (Land ownership is based on the land user certificate conferred by the government)
Relative level of wealth: average

Importance of off-farm income: less than 10% of all income: 20% of income of the lucerne plot, rest from other cropland of totally 19 ha and 5 ha of pasture
Access to service and infrastructure: low: employment (eg off-farm), energy, financial services; moderate: health, education, technical assistance, market, roads & transport, drinking water and sanitation
Market orientation: subsistence (self-supply)



Technical drawing

The Esparcet plot is located on a hillslope and is laterally delimited by embankments. The density of the vegetation cover varies within the plot. A rill building was observed in the upper part of the plot, originating in the wheat cultivation with very low vegetation cover located upslope. (Malgorzata Conder)

Implementation activities, inputs and costs

Establishment activities

- Plowing- lab. light: 1.5 hours, 1 person (pers d)
- Plowing - tractor rent
- Plowing - petrol
- Fodder grain seeds
- Esparcet seeds
- Sowing Grain and Esparcet - lab.light: 1.5 hours, 1 person (pers d)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	6.20	100%
Equipment		
- machine use	20.70	100%
- petrol	45.50	100%
Agricultural		
- seeds	153.20	100%
TOTAL	**225.60**	**100.00%**

Maintenance/recurrent activities

- Cutting Esparcet

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	1174.40	100%
Equipment		
- machine use	62.10	100%
- petrol	45.50	100%
TOTAL	**1282.00**	**100.00%**

Remarks:
The most determinate factor is theoretically the cost to harvest the Esparcet. Labour input is not based on money, but on mutual support among the farmers. So the farmer will have to work on plots of other farmers to compensate the support he gets. Besides, seeds and tractor renting are the most expensive aspects of Esparcet cultivation.
Second labor input for harvesting Esparcet was calculated proportionally to the yield: 100% first harvest and 50% for second harvest.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+++ increased fodder production
++ increased crop yield
++ increased fodder quality
+ increased animal production
+ reduced risk of production failure
+ decreased workload

Production and socio-economic disadvantages

+ increased expenses on agricultural inputs

Socio-cultural benefits

++ improved food security / self sufficiency
+ improved conservation / erosion knowledge

Socio-cultural disadvantages

Ecological benefits

++ increased soil moisture
++ reduced surface runoff
++ improved soil cover
++ reduced soil loss
+ reduced evaporation
+ reduced hazard towards adverse events
+ increased biomass above ground C
+ increased nutrient cycling recharge
+ increased soil organic matter / below ground C
+ reduced soil crusting / sealing
+ reduced soil compaction

Ecological disadvantages

Off-site benefits

++ reduced downstream siltation
++ improved buffering / filtering capacity
+ reduced damage on neighbours fields

Off-site disadvantages

Contribution to human well-being / livelihoods

+ Increased income due to improved production (short and long term) leads to a better well-being of the family, but there is only limited improvement since it accounts only to 20% of the farmers' income.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	positive	very positive
Maintenance / recurrent	very positive	very positive

Yield is lower in the first year of the establishment but more cuts are possible in the next years. In the longer term, it is more beneficial for soil properties: Good soil nutrient and soil moisture availability, soil stabilization and reduced soil erosion and off-site effects.

Acceptance / adoption:

There is no trend towards (growing) spontaneous adoption of the technology. No adoption is done, but farmers might think about it.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Several harvests per year (up to three harvests) possible especially in the hills where precipitation is high →	Farmers need to cultivate food crops. A small scale farmer would only produce Esparcet if he already has a wheat crop somewhere, even if the latter is less profitable → Knowledge transfer
Esparcet has many beneficial on- and off-site effects concerning soil quality, reduced soil erosion etc. → Knowledge transfer to other farmers	First year only one cut is possible, and thus the farmer has to accept a lower yield compared to the cultivation of wheat →
Moderate work load (no guarding of the plot from boar) → Promote perennial crops among local farmers	
Good yield, if you sell it you can buy comparatively a good quantity of wheat →	
Guaranteed fodder availability for livestock →	