Development of methodology for mountainous farming systems classification: Case study of Tien Shan Mountains, Kyrgyzstan

Doctoral Thesis by Azamat Azarov

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Development of methodology for mountainous farming systems classification: Case study of Tien Shan Mountains, Kyrgyzstan

DOCTORAL THESIS

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Objectives of thesis

The breakup of the Soviet Union in 1991 has led to transformation of the farming system in Kyrgyzstan. Large state farms became fragmented into hundred thousand of family-managed farms. Despite subsequent changes in agriculture, knowledge of these spatially diverse smallholder farms and their socioeconomic conditions remains limited, impeding development interventions to improve productivity and sustainable resource management. Therefore, the thesis aims to develop and test suitable classification methodology for mountainous farming systems in Kyrgyzstan that would allow effective policy recommendations and development interventions.

Methodology

The study will be based on data collected from at least 400 households in the south-western and central Tien-Shan mountains. Quantitative farm-level data on the organization and economic performance of smallholder farms will be collected through in structured questionnaires. Multivariate classification of the farm population will be carried out by a principal component analysis (PCA) and cluster analysis to create robust farm classification. The farm classification will be the basis for the subsequent class-specific analysis of the farming systems. The derived results will give an overview of the actual organization and economic situation of farms in the study area. The research findings will also serve as a basis for the modelling of Kyrgyzstan's accession to EAEU on farm income and specific recommendations will be provided to increase sustainability for each identified farming system.

The proposed extent of the thesis

100 pages

Keywords

Multivariate approach; principal component analysis; cluster analysis; focus group discussions; policy recommendations; sustainability

Recommended information sources

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Declaration

"I hereby declare that I have done this thesis entitled "Development of methodology for mountainous farming systems classification: Case study of Tien Shan Mountains, Kyrgyzstan" independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to the Citation rules of the Faculty of Tropical AgriSciences."

In Prague, June 2023

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Azamat Azarov

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Dedicated to my father

Table of contents

List of tables

List of figures

List of abbreviations

ANOVA	Analysis of Variance
CGIAR	Consultative Group for International Agricultural Research
DE	Digestible energy
DM	Dry matter
FAO	Food and Agriculture Organization of the United Nations
FSA	Farming Systems Approach
GAO	Gross Agricultural Output
HFD	High forest product dependent farms
UJF	Upper jailoo farms
LJF	Lower jailoo farms
KGS	Kyrgyz Som (national currency)
LFD	Low forest product dependent farms
LRF	Land Distribution Fund
LU	Livestock Unit
ME	Metabolizable energy
MFD	Middle forest product dependent farms
MJ	Megajoules
NEL	Net energy content for lactation
NSC	National Statistical Committee
NTFP	Non-timber forest product
ODK	Open Data Kit (open-source mobile application for data collection)
PCA	Principal Component Analysis
SFD	State Forestry Department
USAID	United States Agency for International Development
USD	US Dollar
USSR	the Union of Soviet Socialist Republics; the Soviet Union
WOCAT	World Overview of Conservation Approaches and Technologies

Abstract

The objective of this doctoral thesis was to develop an appropriate and robust classification methodology of the prevailing farming systems in south-western and central Tien Shan mountains as well as to fill the gap of missing information on the socioeconomic status of farms by creating a new farm typology. Another objective was to simulate the impact that Kyrgyzstan's accession to the EAEU (Eurasian Economic Union) may have on the income of identified smallholder farms. Data were collected in two rural regions in the south-western and central parts of the country, which we have conditionally divided because of the differences in agricultural production and livelihoods due to the complex topography and climate. Thus, 220 farm-households in three villages in the south-western study site and 235 farm households central Tien Shan study site were surveyed. Quantitative farm level data on the organization and economic performance of smallholder farms were collected in structured questionnaires. These data were assessed by two multivariate methods to create robust farm typologies based on principal component analysis (PCA) and cluster analysis. Then a t-test and analysis of variance were used to compare the means of independent groups to determine whether there is statistical evidence that the respective population means differ significantly. Since we conducted the analysis in two different conventionally divided research regions separately, our analysis identified five distinct farming systems throughout the study areas. In the south-western Tien Shan site, three distinct silvopastoral farming systems were delineated based on classification variables associated with sources of income and livelihood strategies in which farmers collection and selling of non-timber forest products (NTFPs) was important, but also included: (i) relatively high NTFP income, medium-size livestock herds, and low off-farm income; (ii) moderate NTFP income, large livestock herds, and high off-farm income; and (iii) low NTFP income, small herds, and moderate off-farm income. In central Tien Shan, two distinct mixed crop-livestock farming systems were identified based on their socioeconomic and agroecological characteristics: (i) upper jailoo farms (UJF), high-elevation mountain ranges between 2000–2400 m, based on fodder and livestock production and characterized by a short pasturing period and low off-farm income; and (ii) lower jailoo farms (LJF), mid-elevation mountain ranges between 1500–2000 m, based on crop and livestock production with comparatively longer pasturing periods and moderate off-farm income. Recommendations to support agricultural development and sustainability in these farming systems are presented based on technological advances and production. Specific recommendations are provided to increase sustainability for each type of farm system. In general, improving the forage base for livestock and improving grazing management in forests and pastures are relevant for all types to conserve and sustainably use forests and pastures. In the case of silvopastoral groups, value-added processing of NTFPs and contributions from off-farm activities, such as tourism, are necessary. For crop-livestock farming systems, improvement of irrigation systems and more advanced cultivation of fodder crops is necessary to reduce the pressure on pastures. Our classification methodology has distinct advantages over traditional typologies based on farm size and legal status because the latter does not consider diversity among size classes and do not include agroecological conditions as well as the socio-economic status of the farms. These findings can benefit policymakers and development practitioners in efforts to promote rural development of mountain regions that will help alleviate current socio-economic disparities. This classification approach can be adopted for application in similar mountain regions.

Keywords: Farming-systems economy, Central Asia, pasture degradation, silvopastoral and agropastoral production, cluster analysis

Abstract (Czech)

Cílem této disertační price bylo vytvořit vhodnou complexing metodiku klasifikace zemědělských system převládajících v jihozápadním a centrálním pohoří Tien Shan v Kyrgyzstánu a poskytnout komplexní socioekonomickou charakteristiku farem prostřednictvím nového přístupu k jejich typologii. Následně simulovat dopad, který může mít vstup Kyrgyzstánu do Euroasijské hospodářské unie, na příjmy identifikovaných typů farem. Výzkum byl proveden ve dvou rurálních oblastech pohoří Tien Shan v jihozápadním a středním Kyrgyzstánu, rozdílných z pohledu struktury zemědělské produkce a způsobu obživy v důsledku topografických a klimatických podmínek. Data byla získána dotazníkovým šetřením na vzorku 220 domácností v jihozápadní a 235 domácností v centrální části pohoří Tien Shan. Kvantitativní data vypovídající o struktuře a socio-ekonomických charakteristikách farem byla získána prostřednictvím strukturovaných rozhovorů. Získaná data byla vyhodnocena dvěma vícerozměrnými metodami s cílem vytvořit pro každou studovanou oblast vhodnou typologii farem na základě analýzy hlavních komponent (PCA) a shlukové analýzy. Následně, k porovnání průměrů nezávislých množin byly použity t-test a analýza rozptylu s cílem zjistit, zda jsou rozdíly v průměrovaných datech mezi příslušnými populacemi statisticky průkazné. Celkem bylo na základě analýzy dat identifikováno pět typů zemědělských systémů. Na základě identifikovaných proměnných souvisejících se zdroji příjmů a strategiemi obživy byly v jihozápadním Tien Shanu vydefinovány tři odlišné silvopastorální zemědělské systémy, v nichž má významnou roli sběr a prodej nedřevních lesních produktů (NTFPs). Naproti tomu, ve středním Tien-Šanu byly na základě socioekonomických a agroekologických charakteristik identifikovány dva odlišné agropastorální systémy charakteristické smíšenou rostlino-živočišnou produkcí. Na základě současného vědeckého poznání a rozvoje moderních technologií zemědělské produkce byla pro každý typ zemědělského systému navržena konkrétní doporučení k podpoře rozvoje zemědělství a jeho udržitelnosti v horských oblastech Kyrgyzstánu. Pro všechny identifikované typy zemědělských systémů je zásadní zlepšení krmivové základny pro hospodářská zvířata a zlepšení managementu pastvy, což má pozitivní vliv na ochranu a udržitelné využívání lesních a travních ekosystémů. V případě silvopastorálních systémů je nezbytná podpora zpracování NTFPs na produkty s vyšší přidanou hodnotou a podpora mimoprodukčních funkcí zemědělství a činností souvisejících např. s environmentálně udržitelnou turistikou. V kontextu agropastorálních systémů je třeba zlepšit hospodaření s vodou a podporu pěstování pícnin, a tím snížit současný nepřiměřený tlak na pastviny. Metodika klasifikace a typologie farem v rámci této práce přináší výrazné výhody oproti tradičním typologiím založeným na rozloze a právním statutu farem. Tyto totiž nezohledňují rozlohovou rozmanitost ani agroekologické a socio-ekonomické podmínky farem. Tato práce tak může být jedním z důležitých podkladů pro formulaci strategií zemědělské politiky a rozvoje venkova v horských oblastech Kyrgyzstánu i v jiných oblastech světa.

Klíčová slova: Ekonomika zemědělských systémů, Střední Asie, degradace pastvin, agropastorální systémy, silvopastorální systémy, horské ekosystémy, shluková analýza

Abstract (Kyrgyz)

Бул докторлук диссертациянын максаты, түштүк-батыш жана борбордук Тянь-Шань тоолорунда өкүм сүргөн дыйканчылык системаларынын ылайыктуу жана бекем классификациялык методологиясын иштеп чыгуу, ошондой эле чарбанын жаңы типологиясын түзүү аркылуу чарбалардын социалдык-экономикалык абалы боюнча жетишпеген маалыматтардын боштугун толтуруу болгон. Дагы бир максат – Кыргызстандын Евразиялык Экономикалык Биримдигине (ЕАЭБ) кирүүсү, аныкталган майда чарбалардын кирешесине тийгизе турган таасирин симуляциялоо. Маалыматтар, өлкөнүн түштүк-батыш жана борбордук бөлүктөрүндөгү эки айыл аймагынан чогултулуп, аларды биз шарттуу түрдө жердин жана климаттын татаалдыгынан айыл чарба өндүрүшүнүн жана жашоо-тиричилигинин айырмачылыгына жараша бөлдүк. Ошентип, түштүк-батыштагы изилдөө аймагындагы үч айылдан 220 жана борбордук Тянь-Шань изилдөө аймагында 235 кичи фермердик чарбалар изилденген. Түзүлгөн анкетада, кичи фермердик чарбалардын уюштурулушу жана экономикалык көрсөткүчтөрү жөнүндө сандык маалыматтар чогултулган. Бул маалыматтар негизги компоненттердин анализинин (НКА) жана класстердик анализдин негизинде чарбалардын типологиясын түзүү үчүн көп кырдуу методдор менен бааланган. Дисперсиондук анализ (ANOVA) жана t-тест көз карандысыз топтордун орточо көрсөткүчтөрүн салыштыруу үчүн жана тандалгандардын орточо маанисинин ортосундагы статистикалык маанилүү айырмасын аныктоо үчүн колдонулган. Биз анализди эки шарттуу түрдө бөлүнгөн изилдөө аймактарында өз-өзүнчө жүргүзгөндүктөн, биздин талдоо, изилдөө аймактарында беш айыл чарба системасын аныктады. Түштүк-батыш Тянь-Шанда классификациялык өзгөрмөлөрдүн негизинде, киреше булактарына жана жашоону камсыздоо стратегиясына байланыштуу үч түрдүү силвопасторалдык дыйканчылык системасына бөлүнгөн, анда жыгач эмес токой продуктыларын (ЖЭТП) чогултуу жана сатуу маанилүү болгон, бирок анда: (i) (ЖЭТП) дан салыштырмалуу жогорку киреше, орточо малдын саны жана чарбадан тышкаркы ишмердүүлүктөн аз киреше; (ii) (ЖЭТП) дан орточо киреше, көп малдын саны жана чарбадан тышкаркы ишмердүүлүктөн көп киреше; жана (ЖЭТП) дан жогорку киреше, аз малдын саны жана чарбадан тышкаркы ишмердүүлүктөн орточо киреше да камтылган. Борбордук Тянь-Шанда социалдык-экономикалык жана агроэкологиялык мүнөздөмөлөрүдүн негизинде эки түрдүү дыйканчылык-малчылык аралаш системасы аныкталган: (1) Жайлоо-бийик (ЖБ), 2000–2400 м бийиктикте жайгашкан тоо кыркалары, малчылыкка жана тоют өндүрүүгө негизделип, мал жайуунун кыска мезгили менен жана чарбадан тышкаркы ишмердүүлүктөн аз кирешеси менен мүнөздөлгөн; жана (2) Жайлоонун орто деңгээли (ЖО), 1500–2000 м орто бийиктикте жайгашкан тоо кыркалары, салыштырмалуу узагыраак мал жайуу мезгили менен жана чарбадан тышкарка орточо кирешеси менен дыйканчылыкка жана малчылыкка негизделген. Айыл чарбасынын жана бул дыйканчылык системалардын туруктуу өнүгүүсүн колдоо боюнча сунуштар өндүрүштүн жана технологиялык жетишкендиктердин негизинде көрсөтүлгөн. Туруктуулукту жогорулатуу боюнча чарбалык системанын ар бир түрүнө конкреттүү сунуштар берилген. Жалпысынан, мал чарбасы үчүн тоют базасын жакшыртуу, токойлорду жана жайыттарды сактоо жана туруктуу пайдалануу максатында токойлор менен жайыттарда жайууну башкарууну жакшыртуу бардыгына тиешелүү. Силвопасторалдык группалар үчүн ЖЭТП кошумча наркы менен кайра иштетүү жана туризм сыяктуу чарбадан тышкаркы ишмердүүлүктүн салымдары зарыл. Дыйканчылык жана мал чарба системалары үчүн жайытка болгон зыянды азайтуу үчүн сугат системаларын жакшыртуу жана прогрессивдүү тоют өстүрүү зарыл. Биздин классификациялоо методологиябыз чарбанын чоңдугуна жана укуктук статусуна негизделип, салттуу типологиялар алдында артыкчылыкка ээ, себеби, акыркы учурларда класстар арасында чоңдуктун түрдүүлүгү эске алынбай, агроэкологиялык шарттар жана ошондой эле чарбалардын социалдык-экономикалык статусу четке кагылган. Бул тыянактар, тоолу аймактардагы айыл чарбасын өнүктүрүүдө чечим кабыл алуучуларга жана иш жүзүнөгүлөргө пайдасын тийгизип, азыркы социалдык экономикалык теңсиздикти жеңилдетүүгө жардам берет. Мындай классификациялоо ыкмасын ушул сыяктуу окшош тоолуу аймактарда колдонууга болот.

Негизги сөздөр: дыйкан чарбалардын экономикасы, Борбордук Азия, жайыттардын деградациясы, сиолво- жана агропасторалдык өндүрүш, кластердик анализ.

1. Introduction

Agricultural production in mountain areas across the globe is typically practiced on family-based smallholder farms (Wymann von Dach et al. 2013). Although mountain farming has many diverse features due to different altitudes, climate regimes, and landscapes, in terms of livestock husbandry, the largest proportion of the mountains and uplands are occupied by extensive pastoral farming systems (Córdova et al. 2019). These mountain pastoralists face various environmental and socio-economic sustainability challenges which threaten their agricultural production and consequently livelihoods (Fan & Rue 2020; Härri et al. 2020). On one hand, because of the rugged terrain, these lands are very vulnerable to climatic hazards and disasters (e.g., debris flows, landslides), and, on the other hand, they are marginalized by limited access to infrastructure, markets and technology (Rawat & Schickhoff 2022). In Kyrgyzstan, more than 80% of agricultural land consists of high mountain pastures (including mountain forest pastures) and most of the livestock-based smallholder farmers living in these areas face additional sustainability challenges such as pasture and forest degradation and loss of biodiversity mainly due to overgrazing (Kerven et al. 2011; Crewett 2012; Undeland 2015).

Current smallholder farming systems have been largely shaped by the political, social and economic reforms of the last decades in the aftermath of the disintegration of the USSR (Kasymov & Nikonova 2006; Kasymov et al. 2016; Neudert 2021). As a result of this breakup, the large state-owned agricultural enterprises that produced meat, wool products, and large-scale crops (Hamidov et al. 2016) were fragmented into the small-scale family-managed farms (Lerman & Sedik 2008). Since independence in 1991, more than 460,000 smallholder farms emerged with an average size of 2.0 ha (NSC 2022), mostly located in rural mountain regions (FAO 2020). Over the decades, only a small number of farmers have been able to expand their farming operations; however, most smallholder farms still remain with very limited resources and capacities (Ludi 2003; Steimann 2011; Shigaeva et al. 2016). Despite their modest capacities, these farms now produce the largest share of country's agricultural output because most of the available arable land and pastures exists in these farms, which supports rural livelihoods (Lerman & Sedik 2009; FAO 2020). This agricultural production has a direct impact on the resources used with current development trajectories in mountainous areas of Kyrgyzstan implicating that resource utilization in these areas may unsustainable. Moreover, current practices may threaten the long term social and economic development of rural mountain farming systems.

According to various sources, degraded pastures occupy at least 30% of these mountain lands throughout the country (Bai et al. 2008; USAID 2009; Le et al. 2015; Mirzabaev et al.

2016; Robinson 2016). This condition is also confirmed by satellite imagery, which attributes land degradation largely to increasing numbers of livestock and unsustainable use of pastures (Kulikov et al. 2016; Zhumanova et al. 2018; Duulatov et al. 2021; Umuhoza et al. 2021). In addition to the vast highland pastures, mountain forests are also prone to degradation due to overharvesting of forest products and overgrazing, leading to increased deforestation and loss of biodiversity (Orozumbekov et al. 2009). Although mountain forests occupy a very small part of the highland area, they are vital for community livelihoods because they provide non-timber forest products (NTFPs) and represent the main seasonal grazing resources (Borchardt et al. 2011; Cantarello et al. 2014; Orozumbekov et al. 2015; Shigaeva & Darr 2020). The negative impact of increased herd size is aggravated by insufficient production of winter fodder for livestock, and in the forest areas, a lack of access to pasture and arable land for local people (Farrington 2005; Undeland 2015; Chi et al. 2020). Recently, the government introduced several regulations and laws aimed at providing the necessary legal framework for sustainable pasture and forest management, e.g. Law on Pastures or designating forest land as protected areas (Government of Kyrgyz Republic, 2009; 2003). However, these measures are rarely obeyed and pasture and forest resources remain under pressure (Jalilova & Vacik 2012; Liechti 2012; Crewett 2015; Dörre 2015; Shigaeva & Darr 2020). The main deficiency of such measures is that they do not consider the current importance of pastures and forests for local smallholder farms, which indicates that the suitability of these measures and their effects on local agricultural production and livelihoods are still not well understood (Fisher et al. 2004; Liechti, 2002). In addition to these measures, another economic incentive taken by the government was the accession to the Eurasian Economic Union (EAEU[1]) in 2015 (World Bank 2014). Potential benefits included the promotion of agricultural exports to EAEU member countries, among others (NISI 2011; Pavlov 2012; Ministry of Economy 2015). Several studies questioned the benefits of EAEU membership and there was considerable uncertainty about the implications of this policy decision for small farmers (Pavlov 2012; Mogilevskii et al. 2014; Tarr 2016). A frequent obstacle to the success of such measures is the lack of reliable information about the diversity of smallholder farms, their socio-economic characteristics and resource availability, as well as differences in farmers' needs including responses to previously mentioned incentives or regulations (Dunjana et al. 2018). Based on this understanding, interventions and recommendations can be identified that have potential to enhance farm production, reasonably use available resources, and support sustainability of livelihoods

[1] The EAEU is an international organization for regional economic integration aimed at promoting the free flow of goods, services, capital and labour among its members – Armenia, Belarus, Kazakhstan, Kyrgyz Republic and Russia (EAEU 2015; Smutka et al. 2016; Saritas et al. 2017)

(López-i-Gelats et al. 2011). Thus, a socio-economic typology of farm households can provide information to help identify groups of farm households that face similar challenges and constraints that in turn need to be addressed by distinct and appropriate technological and policy interventions (Dunjana et al. 2018).

Although farming systems in Kyrgyzstan are predominantly based on animal husbandry, agricultural production differs according ecological conditions, and these highly variable mountain ecosystems in turn affect farming systems (Kulikov 2018; Duulatov et al. 2021a). For instance, gently sloping lowlands and valleys (e.g., Ferghana, Chuy, Talas) with fertile soils benefit from well-developed irrigation systems, while rainfed agriculture prevails in smaller areas of mountain regions; rangelands and pastures are located at higher elevations (Gupta et al. 2009; Kienzler et al. 2012). In addition, climate may vary amongst different eco-climatic zones, even at the same elevation, and affect vegetation cover, ecosystems diversity, and ecological conditions, which in turn increase the diversity of farming systems. Typical examples are mountain agropastoral and silvopastoral smallholder farms.

Despite the significant transformation processes that have occurred at the farm-household level, information on the socio-economic situation of these farming systems that identifies key characteristics and differences among farm households are generally rare (Liechti 2002; Fisher et al. 2004). Previous studies have extensively documented transformation processes in the country's agricultural sector and, in particular, focused on the effects of land reform and resource management on the performance of newly emerging smallholder farms (Wilson 1997; Bokontaeva 1998; Djailov 2002; Akmataliev 2006; Kydyrmyshev 2009; Jacquesson 2010; Mogilevskii et al. 2017). However, these studies mainly characterized farms and production systems based on official statistical data, while the typology of farms was based mainly on farm size and land ownership (Liechti 2002). The major deficiency of this official classification system is that it fails to include additional socio-economic and agroecological variables that may be important and there is no evidence that smallholder peasant farms are homogeneous and that no further differentiation is required. Other case studies have examined transformation processes in Kyrgyzstan suggesting the importance of a typology of farms based on their resource capacities, i.e. number of livestock, the role of non-agricultural activities and farmers' livelihood strategies (Fisher et al. 2004; Schmidt 2005, 2007; Fisher & Christopher 2007; Shigaeva et al. 2007; Schoch et al. 2010b; Steimann 2011; de la Martinière 2012; Schmidt 2013). However, the differentiation of farm-households in these studies was based on discriminant analysis and tended to over-simplify farm classification, where differentiation was solely dependent on resource-rich and resource-poor farming systems. The main shortcoming of current farm classification systems is that they do not have a robust methodological classification approach that includes a broader set of additional socio-economic and agroecological interrelated variables. Likewise, detailed quantitative analyses of the various economic activities, resource management priorities of the farming systems, as well as influence and perception of pasture degradation on the micro-level of farming systems are largely lacking. Taken together, these deficiencies potentially limit the effectiveness of policy actions aimed at more sustainable land and resource management.

Therefore, due to these limitations, this doctoral study aims to provide numerical clustering procedures for smallholder farm classification that provides an understanding of the diversity of farm characteristics and livelihood assets, including responses to current untargeted and uniform interventions for sustainable use of resources in rural mountain areas. Based on farm typology, the study combines detailed analyses of production systems, socio-economic performance, constraints, and opportunities specific to a particular farm type. It further investigates farmers' behavior and decision-making, providing insights that clarify priorities for farm-household activities, particularly in relation to pasture and other resource management. Furthermore, considering the envisaged advantages to the agricultural sector and smallholder farmers, coupled with the prevailing uncertainty surrounding Kyrgyzstan's accession to the EAEU, another objective of this study is to assess the potential impact on the income levels of smallholder farms in Kyrgyzstan resulting from the country's affiliation with the EAEU, in conjunction with other pertinent factors. Finally, the study suggests future interventions to support sustainable rural livelihoods that considers diversity in endowment of livelihood resources and differences in livelihood strategies.

2. Research framework

The research framework employed in this study encompasses a holistic consideration of the complex interactions and existing situation at the farm-household level, incorporating external components that influence the production system. A graphical illustration and the primary steps of the conceptual approach of the study are depicted in Figure 1, which has been implemented in other studies on farming systems research (adapted from Maurer, 1999). This socio-economic approach entails problem-solving by assessing various factors that impact agricultural production systems and farm-household interactions. These factors include agroecological, biophysical, socio-cultural, economic, and political variables, which can influence farmers' decision-making. It is critical to focus on the main socio-economic, organizational, and technical challenges of farm families, including their perceptions and to understand the problems faced by different farm-households involving village and regional levels of interaction and circumstances (Kabura Nyaga 2007). In addition, such a holistic view involves the elaboration of farming systems with the focus on farm and off-farm activities and livelihood diversification of farm families as well as sustainability of resource usage and overall living conditions. The objectives and decision-making process in the families need to be included because these objectives are of central interest to the human side of the family unit (Doppler 1992).

The methodology proposed by Maurer (1999) is employed herein to investigate the socio-economic situations, needs, and objectives of smallholder farms in the study area. Key steps include the selection of the study area and samples, as well as gathering qualitative and quantitative information on various aspects of farm-households and family objectives. The information gathered is collated into a data pool, which is subjected to multivariate classification methods to delineate farm populations into distinct groups that share similar characteristics. These groups are homogenous in terms of their socio-economic situations, needs, and objectives, as well as the extent of pasture and forest degradation and interlinked challenges. A comparative socio-economic analysis of smallholder farms is then conducted. Unlike Maurer's approach, this study modifies the latter step. Instead of solely modeling long-term technological and policy interventions' impacts, we focus on modeling the effects of Kyrgyzstan's accession to the Eurasian Economic Union (EAEU) and other factors on farm incomes and strategies. A comparative analysis and simulation are conducted, and these results then inform future development options.

Based on the comparative socio-economic analysis and modeled incomes of smallholder farms, future development pathways are discussed. This discussion also includes the farm methods employed. By doing so, we aim to provide insights and recommendations for policy makers and other stakeholders to improve the socio-economic situations of smallholder farms in the study area.

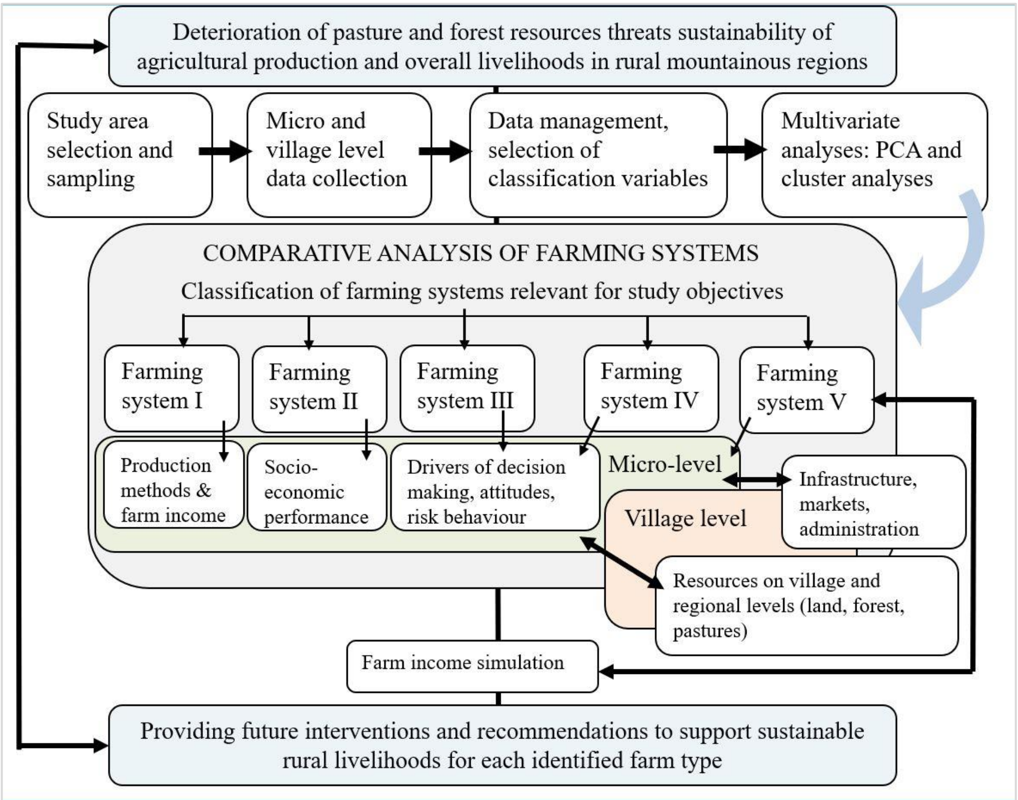


Figure 1 Methodological framework and procedures used in this study. Adapted from Maurer (1999)

The research framework was developed to address several research questions. Firstly, due to the considerable variation in climate within mountainous areas, even at the same elevation, and its impact on ecosystems and agroecological conditions, there exists a diverse range of farming systems. Hence, the study aims to explore **Research question 1**: what types of farming systems are prevalent in the mountainous regions of Kyrgyzstan?

Secondly, as there is currently no comprehensive methodology for differentiating mountain farming systems and the existing official farm classification system based solely on farm size lacks a complete understanding of socio-economic situations, objectives, and problems of farming systems, this study aims to provide a methodology that classifies farm populations using multivariate analysis based on socio-economic and agroecological characteristics. This will address **Research question 2**: which methods best classify these farming systems in the study area?

Thirdly, in this study, a numerical clustering procedure was employed to classify smallholder farms, with the objective of facilitating comprehensive quantitative analyses of diverse economic activities. These activities encompass non-agricultural pursuits, resource management priorities, financial stability, as well as the impact and perception of pasture degradation within different farming systems. **Research questions 3** and **4** pertain to the following aspects: what are the distinctive features of farming systems and how can they be distinguished based on resource allocation, socio-economic performance, and production orientation? and what role do off-farm incomes play, and what is the level of financial stability observed within farming systems?

Fourthly, based on the findings and an understanding of variations in farmers' needs, behavior (including their response to State incentives or regulations), and performance, this study aims to identify measures and recommendations for enhancing agricultural production, optimizing resource utilization, and promoting overall livelihood sustainability. This will address **Research question 5**: what are potential future pathways for diverse farming systems?

Lastly, leveraging the findings, it becomes possible to pinpoint initial focal points for future research with a development-oriented focus in Kyrgyzstan and mountainous regions of Central Asia. This research would address **Research question 6**: what are the initial focal points for future development-oriented research in Kyrgyzstan and throughout Central Asia?

3. Aim of the thesis

Most government regulations and laws aimed at providing the necessary legal framework for sustainable pasture and forest management, as well as ostensibly economic incentives like joining the EAEU (Eurasian Economic Union), currently appear ineffective. This failure is largely accounted to the lack of detailed information on the socio-economic situation of smallholder farms and using inappropriate methods for classifying and analyzing these rural farming systems and for developing specific farm interventions to support sustainable rural livelihoods. Thus, developing a classification methodology to characterize and identify prevailing farm systems in lower and middle elevations of central and southwestern Tien Shan mountains is one of the main objectives of this study. This includes articulating characteristics and differences of farming systems in terms of resource management, production systems, livelihood strategies and development constraints. Based on the comparative analysis of distinct farm households, possible development recommendations can be provided with regard to the main objectives of the different farm families as well as sustainability of the resources and livelihood income sources.

Smallholder farmers in Kyrgyzstan face a range of challenges, including environmental uncertainty caused by climate change, limited accessibility to underdeveloped infrastructure in agricultural areas, and inadequate natural resource management mechanisms. The country's accession to the EAEU in 2015 has only compounded these challenges. Despite the expectation that Kyrgyzstan's membership in the EAEU would result in increased agricultural exports and income for smallholder farmers, the impact of this decision on small farmers remains uncertain. Thus, this study aims to estimate the potential impact on the income of identified smallholder farms through Kyrgyzstan's accession to EAEU and other factors. Acknowledging the challenges of establishing causality and measuring the impact of individual sources of uncertainty on farmers' incomes, we must note that changes in the factors considered in our simulation may be influenced not only by political decisions such as accession to the EAEU, but also by long-term macroeconomic trends and short-term market fluctuations. To address this, our study has prioritized a medium-term analysis that can better capture the effects of policy decisions and market fluctuations, which are more likely to have significant consequences for smallholders in the short to medium term. Through this analytical approach, we aim to enhance our comprehension of the various constraints confronting smallholder farmers in Kyrgyzstan and formulate effective development strategies.

Aim 1: Classify farm populations in the central and south-western Tien Shan mountains into distinct groups based on farm organization, economic performance, and development constraints using multivariate analysis**.**

Specific objective 1.1: to characterize the socio-economic conditions of prevalent farms;

Specific objective 1.2: to develop, test, and apply methodologies to classify these farms;

Specific objective 1.3: to suggest future interventions to support sustainable rural livelihoods for each identified farm type.

Aim 2: to model the income effects on farm types resulting from Kyrgyzstan's accession to the EAEU.

Specific objective 2.1: to apply Monte Carlo method to simulate expected changes in prices and factor costs by establishing static and dynamic scenarios of farm income.

4. Literature review

4.1 History and legacies

Until the mid-19th century, Central Asia remained unchanged as a land of pastoral nomads migrating vertically and horizontally across large stretches of land. Kazakhs' and Kalmycks' tribes of the region occupied the dry and desert-steppes, and the Kyrgyz lived in the foothills and mountains of the Tien Shan and Pamir (Abramzon 1971). Kyrgyz tribes practiced a transhumance migration to high mountain pastures during the summer months and settling in the valleys and lowlands in winter. A minority of the Kyrgyz, mainly yak herders, stayed at high-altitudes all year (Kreutzmann 2003; Rahimon 2012). Kyrgyz were nomads employing year-round grazing. The base camps or fixed settlements of most herders occupied narrow valleys in the low mountains (1000–2000 m). Animals grazed on grasses and shrubs along the river valleys below the forest zone and were fed supplementary fodder in winter.

In spring, herders migrated gradually to upper pastures above tree line and stayed in highland pastures during summer months. With the beginning of autumn, herders migrated rapidly towards winter camps across the recovered spring/fall pastures (Schillhorn 1995). Russian colonization during the late 19th century substantially changed this transhumance system. Many traditional grazing lands, especially the lowland valleys, were settled by Russian farmers who converted the land to crops (cereals, cotton, tobacco, and fruit) and livestock production. However, the transhumance farming continued to dominate in the highlands but became more intensive after the 1930s (Schillhorn 1995; Tilekeyev et al. 2016) when was introduced and agricultural production was by large state farms, i.e. collective farms (*kolkhozes*) and state farms (*sovkhozes*). These collectives represented the formal commercial farm sector; very small subsistence-oriented household plots represented the "private" sector (Lerman & Sedik 2009a, 2009b). Throughout the Soviet era, each Central Asia country specialized in certain agricultural strategies: Kazakhstan in grain production; Kyrgyzstan in sheep production, alfalfa, and maize; and Tajikistan, Turkmenistan, and Uzbekistan producing irrigated cotton and karakul sheep (Hamidov et al. 2016; Ahado 2021). With establishment of large state farms, traditional animal herding was modified with improvements to reduce risks of herd loss.

Larger herds up to 25,000 head grazed during summer months in mountain pastures of Kyrgyzstan and migrated into lowlands of the northern part of the country up to Kazakhstan for winter grazing with supplemental feed provided to animals (Rahimon 2012). In mountainous areas of Kyrgyzstan, the entire agricultural production system was organized to supply inputs to increase mainly livestock numbers, in particular sheep herds for meat and wool production (Kerven et al. 2012). However, livestock production was constrained by the lack of fodder in winter. To solve this problem, the State made massive investments in cultivation of fodder crops, including fodder imports from other Soviet states (Schillhorn 1995).

4.2 Transformation period

Dramatic transformations in the agrarian sector started in the early 1991s after breakup of the Soviet Union and proceeded in several phases. The first phase of reform (1991-1994) was characterized by a transition from collective to private ownership; the collective farms were first reorganized in the form of agricultural cooperatives and farm associations. About 30% of collective farms were reorganized and up to 20 thousand small farms were formed during 1991-1993. The rest of the sector remained in the former operation and management mode. By the end of 1994, land shares and other assets (land, livestock, and machinery) were distributed on paper to farm members and villagers. Agricultural output was falling, but slower than outputs from other sectors. In 1995, the agricultural sector accounted for half of the national GDP (World Bank 2020). The second phase of land reform began in 1994 with the reorganization of 450 state farms and collective farms. A majority of the transferable land was distributed to individual farmers, while livestock distribution began earlier and, by 1995, 68% of the livestock were distributed to individuals. However, only about 16% of agricultural machinery and buildings of former state farms were in private hands. By the end of 1996, about 75% of arable land was allocated for distribution among individual farmers. The remainder was transferred to the Land Redistribution Fund (LRF) and remained state property for future distribution (Lerman & Sedik 2008). The next substantial reforms (1994-2001) saw the number of one-household farms increase from 20,000 to 250,000. Concurrently, average farm size declined from 15 ha from 1994 to 1996 to 3 ha in 2002. The total arable land for individual use reached around 920,000 ha, both irrigated and non-irrigated, while remaining large agricultural corporate enterprises and other users cultivated less than 400,000 ha. Given that pastures are the main resource for farmers (up to 85% of total agricultural land), the next phase of agrarian reforms focused on development of agricultural extension services and improvement of infrastructure – e.g., development of cooperatives; development of peasant farms and agri-businesses; improvement of water and pasture management; and social development of rural areas (Mogilevskii et al. 2017).

In summary, the transition from the former Soviet plan to market-based economy can be illustrated by the shifting role of agricultural enterprises and individual farms. More than 450 Soviet-era agricultural state collective farms that played major roles in agricultural production were disaggregated into hundreds of thousands of small household farms. This privatization of land holdings was accompanied by an even greater shift of livestock inventories from enterprises to family farms: the successors of collective and state farms lost virtually all their animals and livestock today is concentrated almost exclusively in household plots and peasant farms (Lerman & Sedik 2018).

The shift of productive resources (i.e., land and livestock) from enterprises to individuals resulted in a significant increase in the share of individual farms in agricultural production. At the end of the Soviet era individual farms (traditional household plots at that time) contributed 45% to Gross Agricultural Output (GAO) and agricultural enterprises produced the remaining 55% (Lerman and Sedik 2009). Nowadays, individual farms (household plots and peasant farms combined) contribute 99% of GAO and the share of enterprises has shrunk to just 1% (FAO 2020).

4.3 Contemporary smallholder farm typology

Based on current information and studies, a thorough analysis of farming systems has not been conducted in Kyrgyzstan. These investigations indicate that little scholarly work has focused on classification schemes and characterization of farming systems, or, if available, methods remain unclear. Many existing studies deal mainly with general aspects of the effects of land reform, the transformation process, and resource management since independence. For instance, Djailov (2002), Akmataliev (2006) and Kydyrmyshev (2009), and Bokontaeva (1998) described farm types and agricultural production based on data of the statistical committee. These studies described an inefficient production system of newly emerging small-scale farms and lack of investments due to rapid and poorly targeted agrarian reforms. The central focus in these works was the market-driven return to collective management methods.

Other studies examined transformation processes in Kyrgyzstan after the collapse of the Soviet Union and have mainly analyzed livelihood change in the newly emerging smallholder family farms and causes of recent socio-economic differences among household farms (Wilson 1997; Jacquesson 2010; Crewett 2012, 2015; Liechti 2012). These studies have pointed to the importance of typologies of farms based on their resource endowment, i.e., number of livestock (Liechti 2002; Steimann 2011); role of non-farm activities and diversification of income sources (Fisher et al. 2004; Schmidt 2005, 2007, 2013; Fisher & Christopher 2007); and livelihood strategies, as well as agricultural production methods and market orientation (Shigaeva et al. 2007; Schoch et al. 2010b; de la Martinière 2012; Sagynbekova 2017). However, farm differentiation in these studies was based on discriminant analysis with grouping mainly dependent on resource-rich and resource-poor farm households. It is worth noting that these studies also looked at different actors, their practices and organizations, and institutions in different locations in the country, but only in the context of agropastoral and silvopastoral production.

The official agricultural census in Kyrgyzstan (NSC,2021; FAO, 2020) distinguishes three main categories of farms based on the size of arable land and legal status: a) subsidiary farms, b) smallholder peasant farms, and c) large agricultural enterprises, cooperatives, agricultural stock companies, and state farms. Subsidiary farms are generally small and subsistence-oriented, as they have no arable land but an average-size kitchen/home garden of 0.12 ha and a herd of one livestock unit (LU[2]). Subsidiary farms have larger home gardens and herds comparable to peasant farms and there is little overlap between these two farm types (Lerman 2013). Production on subsidiary farms constitutes 34% of total national agricultural production despite their modest resources because they are the most common ($\approx$ 800,000). In contrast to subsidiary farms, there are only several hundred large agricultural enterprises in Kyrgyzstan with >1000 ha (FAO 2020). Usually, the productivity of such large enterprises is high; however, due to their limited number, their contribution to national agricultural production is negligible (<1%). The largest share of agricultural production (65%) comes from smallholder peasant farms where most of the available arable land and pastures reside and support these rural livelihoods (FAO 2020). While subsidiary farms and market-oriented large agricultural enterprises are mostly homogeneous (Lerman & Sedik 2018), grouping smallholder peasant farms into one category is questionable. The major deficiency of the current farm classification system is that it fails to include additional socio-economic and agroecological variables for these smaller farms. In addition, it does not include the objectives and needs of smallholder peasant farms, much less the relationship of farmers to those measures that are aimed at improving their agricultural production and overall economic conditions by simultaneously conserving natural resources.

Statistical committees of other Central Asian countries – Kazakhstan, Tajikistan, Turkmenistan, and Uzbekistan – classify farm types using the same scheme based on size of farms (i.e., peasant, household plots, and enterprises). Notably, the process of individualization of land tenure and privatization of legal land ownership differs in each country. For instance, land was or can be privatized in Kazakhstan and Kyrgyzstan, while in Tajikistan, Uzbekistan, and Turkmenistan (partly), all land remains state owned and is transferred to farmers via user rights. Nonetheless, all countries in the region strive to reform

[2] One livestock unit (LU) corresponds to one cattle, 0.8 horses, or 5 sheep/goats

tenure rights in agricultural land and change the traditional Soviet style farming structure to a model closer to market principles. The privatization of agriculture has largely driven the impressive recovery in agricultural production that we are witnessing since about 1998 across the region. Small family farms have become the backbone of the post-transition farming structure, replacing the agricultural enterprises that dominated during the Soviet era (Lerman 2013).

4.4 Mountain pastoralism and associated rangeland and forest degradation

Mountain rangelands of Kyrgyzstan feature diverse landscapes acting as enclaves for biodiversity with unique vegetation formations and plant communities (Ionov and Lebedeva, 2005; Kulikov, 2018) in a pronounced vertical climatic and ecological zonation. These mountain pastures play an important role in sustaining the livelihood of rural populations by providing fodder for livestock as a main source of income (Fitzherbert 2006). The total 9.147 million hectares of pasture are characterized by complex mountain topography with highly heterogeneous soils and vegetation communities blending into each other. With the new Law on Pastures (Government of Kyrgyz Republic 2009), pasture management has come under the decentralized control of 454 local Pasture Committees in Kyrgyzstan (Fisher et al. 2004; Levine et al. 2017; Zhumanova et al. 2018). These community based pasture management organizations were designed to promote sustainable management of pastures by reducing stocking rates and improving the infrastructure for seasonal movements to remote pastures (Bussler 2010; Crewett 2015; Isaeva & Shigaeva 2017; Mestre 2019; Tagaev 2018). Current livestock numbers have reached or even exceeded the peak numbers during Soviet times (Farrington 2005; Shigaeva et al. 2016) according to official data (e.g., currently more than 10 million sheep) (Tilekeyev et al. 2016). However, the official data are considered inaccurate because livestock owners tend to report lower numbers to avoid additional payments and to avoid disclosure of exceeding grazing limits (Dzhakypbekova et al. 2018). Despite numerous efforts undertaken since the introduction of pasture regulations, pasture degradation still extends across wide areas due to overgrazing, unregulated seasonal grazing, and changes in climatic conditions (Pasture Department, 2014). Most of the degraded pastures are mountain steppes and subalpine meadow-steppe zones in northern, central, and west Tien Shan mountains where vegetation cover changes are ongoing (Nuralieva & Bekirova 2015; Zhumanova et al. 2018). Recent vegetation studies indicate that heavily overgrazed areas mainly occur in low altitudes near settlements (Kulikov & Schickhoff 2017; Kulikov et al. 2017; Umuhoza et al. 2021). Some studies revealed an altitudinal increase of the upper limit of all vegetation belts, particularly of desert and steppe belts in response to climate warming (Ionov and Lebedeva, 2005). Furthermore, species abundance, range limits, and climatic niches have all increased or expanded in the upper ecological zones due to melting of glaciers and snowfields (Ilyasov et al., 2013). These studies also show that overgrazing superimposed with climate change affects the carrying capacity of pastures (Umuhoza et al. 2021). Although pasture degradation has been reported in many studies, there is no common understanding of the level of pasture degradation in Kyrgyzstan (Robinson 2013; Kerven et al. 2016). Numbers vary from 12% to ~30% of the total area of the country (Bai et al. 2008; Le et al. 2015), depending on the methods used. A complete picture is unclear due to a lack of systematic ground-based observations and unknown spatial and temporal distribution of grazing. However, the overall increase in livestock numbers suggests that the general pressures on grazing resources are increasing, which could lead to further pasture degradation (Mirzabaev et al. 2016; Kulikov 2018).

Similarly unclear, is the status of forest degradation. Although forests cover a very small part of Kyrgyzstan, they are important for livelihoods of silvopastoralists because they provide not only firewood and non-timber products, but also represent a major seasonal grazing resource (Djanibekov et al. 2015; Dörre & Schütte 2014; Dörre 2015; Kerven et al. 2016; Kasymov et al. 2016). Forests cover only 5.7% of the country (Figure 6) and are distributed at elevations between 1500-3100 m a.s.l. Spruce forests (*Picea schrenkiana* Fisch. & C.A.Mey.) occur in the north and east parts of the country, while in the south and southwest, juniper forests (*Juniperus communis* var. *saxatilis* Pall.) dominate occupying almost half of the entire forest area. Hillslopes of Fergana and Chatkal are dominated by *Juglans regia* L. with other fruit tree species such as *Malus sieversii* M.Roem and *Malus niedzwetzkyana* Dieck ex Koehne, *Pyrus asiae-mediae* (Popov) Maleev and *Pyrus turcomanica* Maleev, *Prunus sogdiana* Vassilcz., *Ribes janczewskii* Pojarkova, and *Acer platanoides* subsp. *turkestanicum* (Pax) P.C.DeJong (Kulikov 2018). Riparian forests occur along river valleys and are composed of *Populus laurifolia* Ledeb., *Betula* spp., *Salix* spp., *Myricaria elegans* Royle, *Clematis orientalis* L., and *Hippophae rhamnoides* L. (Adyshev et al. 1987).

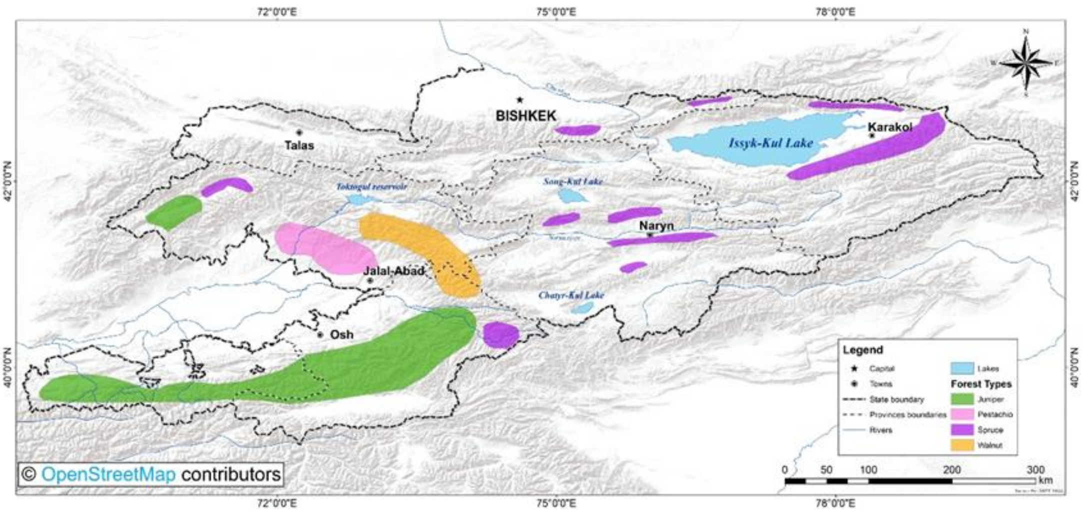


Figure 2 Distribution map of major forest vegetation types in Kyrgyzstan. Adapted from OpenStreetMap (2023)

The extent of forest degradation during the Soviet period is difficult to assess, but some studies show that this peaked in the late 1950s (Robinson 2016). After this period, most forests were protected by the State Forestry Department (SFD) to prevent unsustainable use of forests, including the introduction of protected area status. The situation supposedly improved until the collapse of the Soviet Union. Some studies indicate negative trends in the country, including a reduction of forest area by just under 8% from 1983 to 1989 (Kharin, 2002). While spruce and juniper forests are most vulnerable near human settlements due to logging and overgrazing (especially slow-growing juniper forests), walnut-fruit forests are also impacted due to overharvesting of NTFPs, which support livelihoods in these rural areas (Orozumbekov et al. 2009; Borchardt et al. 2010; Cantarello et al. 2014). Studies estimate that about one million people depend directly or indirectly on these forests for their livelihoods (Shigaeva & Darr 2020). Overharvesting of forest products and overgrazing negatively affect forest conditions and biodiversity and lead to increasing forest degradation, deforestation, and conversion of forest land (Chyngojoev et al. 2010; Orozumbekov et al. 2015). Overgrazing causes trampling and browsing of young trees, especially walnut and wild apple, thus suppressing forest rejuvenation (Orozumbekov et al. 2015; Orsenigo et al. 2016). Furthermore, heavily grazed pastures experience soil compaction, reducing rainfall infiltration and increasing surface runoff and erosion (Borchardt et al., 2011; Kulikov et al., 2017; Sidle et al., 2019).

Studies in these forests report that due to fluctuating walnut and other NTFP harvests local farmers are forced to increase animal numbers on average every three to four years, illustrating the cultural importance of livestock as a major capital asset and savings mechanism in the region (de la Martinière, 2012; Schoch et al., 2010; Steimann, 2011). In addition, there are studies illustrating the importance of diversifying income sources and compensating declines in income caused by migration (Chandonnet et al. 2016; Ratha et al. 2021). Negative impacts of increased herd size are exacerbated by the lack of access to pastures of local communities and the limited production of winter fodder for livestock (Undeland 2015). Government measures are now aimed at protecting the remaining forests by prohibiting unsustainable land use, such as poor logging practices, NTFP harvesting, and overgrazing. Thus, most walnut and fruit forests were designated as nature reserves during the Soviet era and, after independence, the state continued to designate new forest areas as protected areas; i.e., Kyrgyz Government Decree No. 405 (The Government of the Kyrgyz Republic 2003). However, these measures did not account for the current importance of forests for local people; thus, despite these measures, forest resources remain under pressure (Jalilova et al. 2012; Shigaeva & Darr 2020). This indicates that the suitability of these measures, their implications for local livelihoods, and farmers' response strategies are still not well understood.

4.5 Kyrgyzstan's joining to the EAEU and alleged potential benefits for farms

As previously described, mountain regions are relatively isolated from the main markets and goods need to be transported through high mountain passes; thus, farmers in marginal zones exploit existing market opportunities to sell their agricultural products. Another controversial decision by the country's government, supposedly aimed at improving market opportunities by opening export markets and thereby potentially improving the income situation of smallholder farmers, was the country's accession to the EAEU with Armenia, Belarus, Kazakhstan, and Russia. Kyrgyzstan officially joined the EAEU as a fifth member on 12 August 2015 (World Bank 2015). The EAEU is an international organization for regional economic integration and its objective is to promote the free flow of goods, services, capital, and labour among the member countries (EAEU 2015; Tarr 2015). There was a heated debate on the likely impact of Kyrgyzstan's accession to the EAEU in the years preceding its entry into the customs union. Benefits widely cited included, inter alia, an improved status of working migrants in Russia, which was considered important given the large contribution of migrant remittances to the Kyrgyz GDP (Schenkkan 2015; Tarr 2015; World Bank 2020); an increase of foreign direct investment from Russia (Tarr 2015); and the stimulation of exports to EAEU member countries, particularly agricultural products (Ministry of Economy 2014; Pavlov 2012; NIS 2013). It was expected that the economic situation would worsen if Kyrgyzstan did not join the union due to trade barriers to the EAEU (Pavlov 2012). On the other hand, numerous studies have questioned the benefits expected from Kyrgyzstan's accession to the union. One of the main arguments is that the re-export of goods from China, which was primarily enabled by the country's low tariff rates for such imports, would decline when tariffs are harmonized within the EAEU (Pavlov, 2010, World Bank 2014). Furthermore, doubts have been raised that the accession will lead to significantly increased agricultural exports to neighboring countries, as a zero-tariff zone had been in place already before and most of the country's producers could still not meet major veterinary and sanitary requirements considered as preconditions for increasing agricultural exports to EAEU member states (Mogilevskii et al. 2014). For example, Kazakhstan has banned the import of almost all animal products and livestock from Kyrgyzstan because of the occurrence of foot and mouth disease in the country. Various other examples exist of EAEU countries imposing import restrictions for agricultural products from neighbouring countries on the grounds of product quality (Tarr 2015).

Because agriculture contributes 14.8% to Kyrgyzstan's gross domestic productivity and employs 40% of its workforce, it is clear that the sector plays a significant role in the country's economy (World Bank 2020). Despite this, the limited role of agricultural exports in Kyrgyzstan's economy raises concerns about the feasibility of an export expansion strategy. According to UN Comtrade (2016), agricultural products accounted for only 12% of the country's total exports by value in 2015. Agricultural imports into Kyrgyzstan, mainly cereals, flour, meat, and other food from Kazakhstan, Russia, China, and other CIS-Countries, outweigh exports both in physical and monetary terms. The main partners for merchandise imports of agricultural products were Russia, Kazakhstan, and China, accounting for 31.5, 30.2, and 9.4% of total agricultural imports, respectively (UN Comtrade 2016). Agricultural exports mainly consist of vegetables, fruits, milk products, and cotton shipped to Kazakhstan, Russia, and Turkey (NSC 2014). Livestock and processed animal products have not yet reached a considerable share in the total agricultural export market of Kyrgyzstan. Low exports of agricultural and animal products are mainly a manifestation of the fact that agricultural producers in Kyrgyzstan are barely competitive at an international scale in terms of cost and/or product quality (Pavlov 2012). There are only a few enterprises that have currently obtained official certification by Russian and Kazakh authorities – e.g., milk products (Rosselkhoznadzor 2016). Thus, it is concluded that this initiative was more political and pressure-related and of less benefit to smallholder farmers; also, this indicates that production and export opportunities of small farmers are not adequately explored.

4.6 Livelihood diversification and sustainability

Smallholder farming systems in mountain regions converge within various biophysical and socioeconomic environments. Although traditional farming systems in mountainous Kyrgyzstan depend mainly on livestock production, rural families develop different livelihood strategies based on the opportunities and constraints of such environments (Kulikov 2018). The socioeconomic and agroecological characteristics of smallholder farms determine different resource use patterns and agricultural management practices in different regions (Qin et al. 2022). Smallholder farming systems can vary in resource endowment, production orientation and objectives, performance and management skills (Kerven et al. 2012), and in their behaviors and attitudes towards incentives or regulations that shape the diversity of natural resource management strategies (Ashley et al. 2015). Empirical evidence increasingly demonstrates that diversification of livelihood activities and incomes is becoming central to welfare of rural mountain areas in Kyrgyzstan (Murzakulova 2022). Non-farm employment already accounts for a considerable portion of the average income of mountain households with its importance expanding over time (Sagynbekova 2017). Studies summarize the reasons for income diversification as seasonality, risk strategies, responses to labour market failures, accumulation strategies, and coping and adaptation behavior (Dörre & Schütte 2014; Kasymov et al. 2016). However, Sabyrbekov (2019) notes that livelihood diversification is more than income diversification, including property rights, social and kinship networks, and also directly affecting sustainability. Livelihood diversification integrates several disciplines and is multidimensional, encompassing biophysical, economic, and social aspects. Resilience is achieved when livelihoods cope with and recover from stresses and shocks and maintain or expand their capabilities and assets both now and in the future without undermining the natural resource base (Tefera et al. 2011). Accordingly, nonagricultural employment has been recommended for some mountain regions to reduce vulnerability to food insecurity and to conserve natural resources (Chandonnet et al. 2016). Moreover, off-farm income can be invested in agriculture for sustainable agricultural intensification (Murzakulova 2022), reducing the risks associated with innovation, which can facilitate the adoption of new technologies (Dörre & Schütte 2014). In some cases, however, diversification away from farming can have negative consequences for sustainable intensification and conservation of natural resources. For example, remittances from abroad by migrants can lead to high dependence on remittances, non-return of migrants, disintegration of the family unit, and subsequent labour shortages, as confirmed by other studies in agropastoral communities (Schmidt & Sagynbekova 2008; Schoch et al. 2010a; Sagynbekova 2017). These studies also note that, in most cases, migrant remittances are mainly invested in livestock production (i.e., increasing livestock numbers), which can further increase the pressure on already degraded pastures. Thus, an improved understanding of basic household diversity factors and the ability to categorize diversity attributes that relate to livelihood strategies and farming goals should help to better target agricultural innovations.

Developing a consistent typology of rural farm households can help to understand and categorize the diversity of livelihood strategies among smallholder farmers in highland farming systems. Categorization of farms is also necessary to understand how the specific objectives and endowments of different household types affect resource allocation and use leading to degradation of pastures and forests. Recognizing and thoroughly understanding variation within and among farms and across localities is a first step to examine the acceptability and effectiveness of new measures and incentives proposed to improve agricultural production in a sustainable manner, both in terms of resource use and income.

4.7 Farming systems approach and multivariate techniques for generating a typology of the farms

Considering the anticipated changes in farming systems, a descriptive farming systems approach (FSA) is an initial step to identify promising approaches for research and development. Studies on the methodology and application in development-oriented FSA research mainly resides in US and European sources or in international agricultural research centers of the CGIAR network. The study of farming systems has its origins in research from the late 1970s based on a holistic view of people together with their crops and livestock beginning with the assumption that local systems are comprised of mutually connected elements that form a coherent whole (Beebe 2005; Kabura 2007). Current research topics range from on-farm issues such as crop-livestock interactions to farmer activities, civil food networks, and how cultural landscapes are shaped by agricultural activities (Darnhofer et al. 2012). FSA is a holistic approach that focuses on humans, society, and their needs and objectives (Doppler 1992). It addresses decision-making at the family level and, at the same time, involves target groups and people concerned with defining objectives and articulating and evaluating solutions. Farmers decisions are based on the objectives and needs of the family and are reflected in the allocation of these resources within and among farms, families and households, and off-farm activities (Kabura Nyaga 2007). In addition to the objectives and needs of the family, other external factors such as government policies, infrastructure, and market access also influence the strategies adopted by farmers to improve or sustain their livelihoods, e.g., government policies affect allocation of village resources (Maurer 1999). All these drivers and factors are directly or indirectly linked to living standards of farming families.

Understanding farm diversity with its multiple dimensions and drivers such as farmers' needs, behaviour (including responses to incentives or regulations), performance, and overall sustainability is crucial in this approach (Ruben et al. 1998), which makes it possible to assess the suitability of technological innovations for improving agricultural production and farm livelihoods in general (Tittonell et al. 2010; Giller et al. 2021). Diversity in farm livelihoods and strategies is one of the foundations of sustainability emphasizing long-term use and resilience of resources and farmer behavioral responses to stresses and shocks (Block & Webb 2001). The concept of farm typology is central to defining homogeneous groups of farms based on similar sets of attributes ranging from social, ownership, operational, production, and structural characteristics (Dunjana et al. 2018). The main objective of such classifications is to identify the large variation in farm production systems, socioeconomic conditions, and biophysical attributes specific to agricultural production (Pacini et al. 2014). In addition to production and biophysical parameters, there are a few other factors affecting farm diversity, including household composition, technology, and non-agricultural income (Tittonell et al. 2010). The choice of variables is a crucial step in the process of analyzing farm data because it can strongly influence the final typology. The objective of the typology should guide this process, and only those factors should be selected that have a proven impact on relevant structural diversity (Pacini et al. 2014).

Multivariate statistical methods such as principal component analysis (PCA) and cluster analysis are common methods in studies of farm typology within different farming systems (Tittonell et al. 2010). Multivariate analysis applied to household data systematically reduces data dimensionality, household heterogeneity, and produces results that are reproducible across space and time (Kostrowicki 1977). There are many studies showing the effectiveness of this technique and researchers have used farm typologies to support their research for various purposes, e.g., selecting case study farms for detailed analyses and modelling (Hardiman et al. 1990; Köbrich et al. 2003; Tittonell et al. 2010), prototyping crop management systems (Blazy et al. 2009; Pacini et al. 2014), perception of farm environments and participation in agri-environmental schemes (Guillem et al. 2012; Costa et al. 2018), developing productive livestock-based farming systems (Usai et al. 2006; Madry et al. 2013), and selecting target policies and technological interventions (Goswami et al. 2014; Chatterjee et al. 2015; Kuivanen et al. 2016; Dunjana et al. 2018; Namuyiga et al. 2022; LaFevor 2022).

Overall, the literature shows that most research on the typology of farms accounts for the complexity of small farms, as well as the need for a holistic, system-oriented approach to clarify their characteristics and determine sustainable development trajectories. Analytical steps derived from this general approach include the description and comparison of present farming systems and exploration of their development. Moreover, this approach encompasses the reasons and obstacles in development (Maurer 1999).

5. Materials and methods

5.1 Study sites

The study area in Kyrgyzstan comprises villages in the southwest and central provinces of the Tien Shan mountains (Figure 3). Kyrgyzstan is predominantly mountainous, which results in complex hydrological, meteorological, geological, and soil conditions (Kulikov, 2018) that impact the diversity of vegetation cover (Vykhodtsev 1956, 1966). The climate is diverse and temporally variable, and despite the altitudinal gradients, the relationship between climate and altitude cannot be simplified due to significant variations in climate factors across different climatic zones (Adyshev et al. 1987, Ilyasov et al. 2003). These ecological conditions contribute to the diversity of farming systems, which vary in response to variable ecosystems and local agroecological conditions. The selection of study sites is a critical factor that affects the outcome of any research study. Therefore, in this study, great care was taken to select two sites in Kyrgyzstan based on specific criteria. The study area includes various villages in the southwestern and central regions of Kyrgyzstan in the Tien Shan mountains (Figure 3). The primary reason for selecting these areas is due to the prevalence of different pastoral systems. The southwestern Tien Shan is known for its silvopastoral systems, while the central Tien Shan is dominated by agropastoral systems. Furthermore, another selection criterion was the existence of regulations and laws in the villages aimed at ensuring sustainable management of pastures and forests. Further information about these areas, including the regulations and laws in place, is provided in the following subchapters.

Initially, the research aimed to develop methods for differentiating mountain farming systems in the central Tien Shan region. However, we came to the realization that relying solely on a classification based on agropastoral systems in this area would not suffice to achieve our research objectives. In addition, we were presented with a funding opportunity that allowed us to expand our research beyond its initial scope. As such, we decided to broaden our study to include farming systems in the southwestern Tien Shan region where silvopastoral households are practiced. By including silvopastoral households in our research, we were able to contrast and enrich our findings, broaden the investigation, and produce a more robust dataset for analysis, providing a more comprehensive understanding of the diversity of mountain farming systems.

Considering these conditions, including the time difference between the survey and the analysis, the study sites were divided conditionally into two areas based on their location in the Tien Shan mountains: (1) southwestern and (2) central Tien Shan mountains.

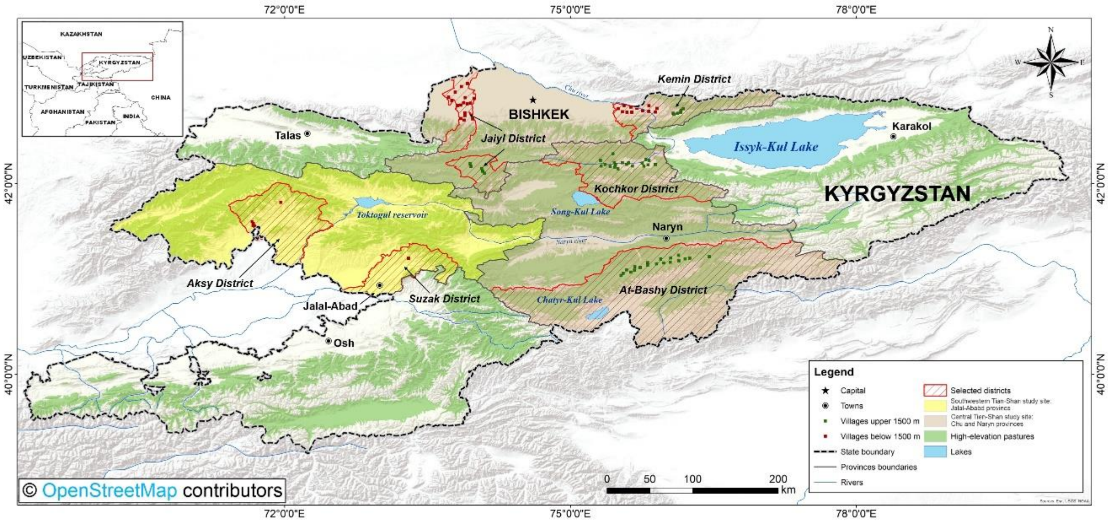


Figure 3 Study sites of Chuy, Naryn and Jalal-Abad provinces in the south-western and central parts of Kyrgyzstan Adapted from OpenStreetMap (2023)

5.1.1 South-western Tien Shan study site

In this region, data were collected in three villages located in Jalal-Abad province (Figure 4). Elevations in these villages range from 500 to 4000 m above sea level, with the total forest cover reaching 14,000 ha. The study area is characterized by a continental arid and semi-arid climate with relatively mild winters (from -5° to 0°C), warm summers (from 18.5° to 20.9°C), and average annual precipitation of 800 to 1000 mm, which peaks in January and April (Adyshev et al. 1987; Isaev et al. 2022). A total of 1125 families lived in three selected villages (NSC 2018); the typical agricultural production system is small silvopastoral farming. Most of these silvopastoral farming systems are characterized by the collection of forest products combined with grazing certain forest pastures around the settlements.

One of the pivotal criterion for the selection of villages within the study site was their location within or near protected areas. It is essential to note that the selected villages significantly impact the forest resources within these protected areas. For example, the village of Arkyt is situated within the Sary-Chelek Biosphere Reserve, while the village of Kashka-Suu is located in close proximity to Padysha-Ata Nature Reserve. The village of Kara-Alma is positioned within the Kara-Alma Forest Reserve. All of these forest reserves are within the study site. Despite the status of nature reserves, collection of some NTFPs, meadow hay, and grazing is partially allowed. For instance, in Kashka-Suu village, the collection of specified amounts of NTFPs and hay from forest meadows is allowed, while in Arkyt village, the collection of only walnuts and hay is allowed in certain forest areas. In Kara-Alma village, collection of NTFPs such as walnuts, wild apples, and pears, as well as collection of hay is allowed. In addition, residents of Kara-Alma can lease forests for up to 49 years from the local forestry department. The leaseholders, in turn, have the exclusive right to harvest walnuts from these plots, and work to preserve these forest areas as well as donate the seeds to the forest center. However, the collection of some threatened species such as *M. sieversii* and *M. niedzwetzkyana*, pear species *P. asiae-mediae*, and *P. turcomanica* are prohibited everywhere (IUCN 2007a, 2007b, 2007c; Newton & Oldfield, 2008). Other NTFPs can be harvested within leased forests by all villagers. Cutting trees for firewood is prohibited in all villages; in Kara-Alma, the collection of withered walnut trees and fallen branches is allowed. The vast majority of NTFPs harvested were for sale and farmers kept a small portion of the NTFPs for family consumption, mainly walnuts and berries, some of them for medicinal purposes (Pawera et al. 2016; Vlkova et.al 2015; Azarov et al. 2022).

Figure 4 Study regions in Jalal-Abad province, Kyrgyzstan, including selected villages. Adapted from OpenStreetMap (2023)

5.1.2 Central Tien Shan study site

In this region, data were collected in a total of four rural districts located in Chuy and Naryn provinces of central Kyrgyzstan. Elevations in these four districts range from 500 to 6000 m a.s.l.; however, since most of the small mountain farms are above 1500 m, all sampled villages are in this elevation range. In Chuy province, most villages are on plains at or below 1500 m; thus, only the mountainous areas of Kemin and Jaiyl districts were above 1500 m. The villages sampled in these two districts were between 1500 and 2400 m a.s.l. Since all villages in Naryn province are located between 1500 and 2400 m a.s.l., Kochkor in the north and At-Bashy in the south of the province were selected. The entire study area consists of 50 villages of different sizes located in high mountain valleys between 1500 and 2400 m a.s.l. In the Kochkor and At-Bashy districts, 36 out of 39 villages were selected, and in the Kemin and Zhaiyl districts, nine of 11 villages were selected. In fact, farmers from 45 villages throughout the central Tien Shan were interviewed, as we excluded towns (administrative centers) with 8,000 and 10,000 residents, as well as small villages (< 400 people), usually located in extremely remote areas.

In contrast, to south-western mountains, the highland valleys in this study site are characterized by a semiarid steppe climate with warm summers (from 10° to 12°C) and long cold winters (from -22° to -8°C) with a lower average annual precipitation of 200 to 300 mm (Bobojonov & Aw-Hassan, 2014). A total of 24,000 families lived in 50 villages (NSC 2010; Nuralieva & Bekirova 2015). Smallholder farming is the typical production system in all mountainous areas sampled, mainly characterized by mixed cropping and pasture use around the settlements and extended summer pastures in highlands (Figure 5). Within the study area, there existed over 40 community-based pasture management committees. These committees were comprised of both pastoralists and representatives of the local administration, which included agronomists and veterinary technicians. The primary objective of these committees was to sustainably manage the pastures within their jurisdiction, both near the settlements and in remote areas, in accordance with the provisions outlined in the Law on Pastures (see section 2.4).

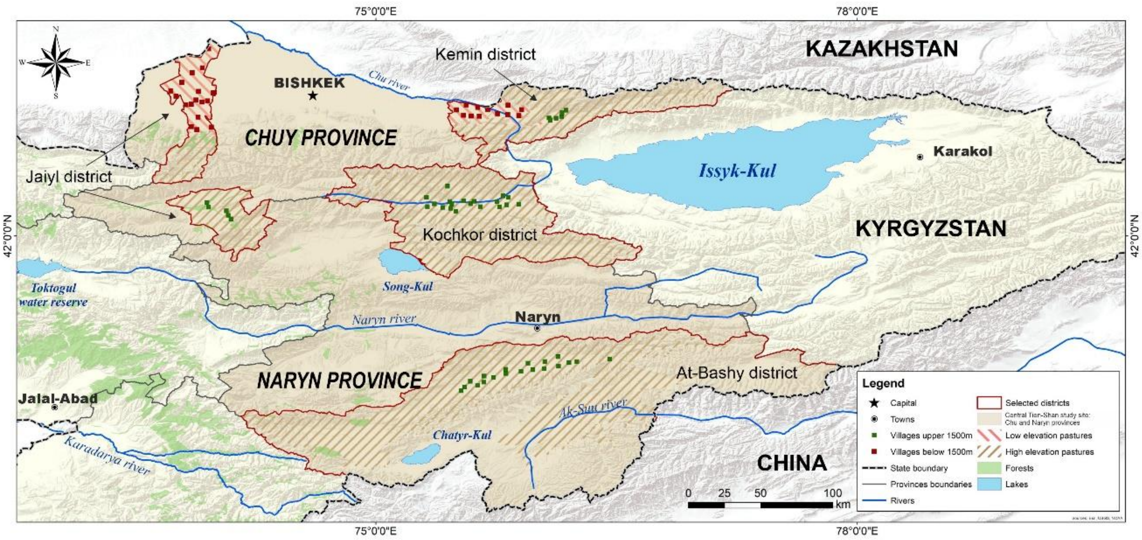


Figure 5 Study region and selected villages located in four districts of Chuy and Naryn provinces in the southern-central parts of Kyrgyzstan. Adapted from OpenStreetMap (2023)

5.2 Household sampling and ethics

The selection of households was based on simple random sampling. For sampling, personal lists of the family farms were necessary so that the sample selection could then be made. Non-farmers and large farms were not considered and removed from the lists. Initially, we planned to obtain data on farm size, resources (livestock number) from '*aiyl okmotu*'[3] to facilitate sample selection and subsequently to exclude households without land, livestock, and large farms. The required lists of farm-households are recorded in a so-called 'farm household directory' book[4] containing information about all family farms belonging to the municipal administration. The household directory was digitized by municipalities in cooperation with the Norwegian Statistical Office since 2009. However, the communal executives did not provide these data because they contained private information about each family. But all communal executives were able to provide total numbers of households in the villages, and later names and the addresses of randomly selected farm-households. Therefore, in the first stage, we visited all 'aiyl okmotus' in each district and discussed with local communal workers about general information on resource bases that included agricultural production (particularly trends in crop and livestock production), as well as factors limiting the

[3] Village government or village executive; at the Aiyl Okmotu level are employed veterinarians, agricultural and pasture experts, statisticians and other social workers

[4] In a household book, all family and farm information such as the number of family members, their occupations, size of land, type, herd size, etc. of village households are recorded. The information is updated every year by employees of the local government. The data is mainly collected for statistical purposes

productivity of farms; at the conclusion of the interview, we obtained permission to conduct the survey. Then all households pertaining[5] to one aiyl okmotu were collected and numbered. Thus, having visited all aiyl okmotus, we had a census of the population and a sequence number of each household within the selected districts of the two oblasts (in the case of the southwestern study site, within three villages). Subsequently, in southwestern Tien Shan study site we randomly sampled 220 households in the three villages, while in central Tien Shan 235 households were selected from 45 villages distributed across the region using a simple sampling formula developed in MS Excel. In southwestern Tien Shan, the number of farm-households sampled in each village was approximately 20% of the total population of each village. While in central Tien Shan, the number of farm-households sampled in each area was approximately proportional (2.0-2.2%) to the total population of each selected village. The variation in the number of villages selected for this research between the southwestern and central Tien Shan sites is primarily due to differences in population density and geographic characteristics of the regions. The southwestern Tien Shan site encompasses a smaller population that is geographically concentrated in three villages, whereas the central Tien Shan site comprises a larger population dispersed across 45 villages. To meet the desired statistical constraints, we calculated the minimum sample size required in each region and employed a different sampling strategy for each site to ensure adequate coverage of the population. In the southwestern Tien Shan site, we established a confidence interval of 95%, requiring a larger percentage of households to be sampled in each village to achieve sufficient coverage of the population. In contrast, in the central Tien Shan site, we established a narrower confidence interval of 90% with a margin of error of 6% to attain the minimum sample size needed. The choice of a narrower confidence level in the central Tien Shan site was primarily driven by the limited resources available, which are expensive and time-consuming to obtain, particularly given the vast size of the study area.

We did not deviate from our selection methods in selecting households; replacement or substitution was allowed in certain cases, e.g., some farm households could not be found, some interviews were refused, and there was subsequent exclusion of households that were not eligible. The latter refers only to agropastoral farm-households of central Tien Shan , which were extremely large ‘resource rich’ farms owning more than 40 livestock units (LU) or 150 sheep/goats, households with more than 30 ha, or those without any landholdings. The agricultural production systems and constraints of the large farms differ significantly from smallholder farms. In these cases, in the sample selection, 10% of substitute farm-households

[5] One aiyl okmotu can encompass one or more villages

were drawn. The number of selected farmers who refused to be interviewed was negligible and was not more than 2% of total selected farms in all study sites.

Within sampled households, data were collected from household heads and/or their spouses to reflect the views of the main decision maker. Prior to the main survey, the questionnaire was evaluated by UCA's Ethics review committee to comply with ethical standards (Appendix 1). All farmers were familiarized with the research objectives. The data were interpreted anonymously.

5.3 Data collection

In southwestern Tien Shan mountains, the socioeconomic survey of households engaged in silvopastoral farming was conducted from June to July 2021, while in central Tien Shan the socio-economic survey of smallholder farmers engaged in mixed farming was conducted from February to July 2014 using a structured questionnaire. The quantitative farm-level data on the organization and economic performance of smallholder farms was collected by means of a structured questionnaire. The questionnaire was pretested to verify the appropriateness of the questions, their order, and to familiarize the author and assistants with the questionnaire. The adjusted data questionnaire was then integrated into the tablets using an open-source mobile application ODK (Open Data Kit) for easy collection and transfer. The questionnaire included queries on agricultural production systems (livestock and crop productions), level, and type of mechanization, resource endowment, debt status, household economy, non-agricultural activities, and remittances (Appendix 2). The survey of farmers was conducted directly by the author and assistants with experience in agricultural production as well as survey procedures. Interviews were in the Kyrgyz language and lasted on average two hours.

Ten local experts were interviewed by the author in 2016 to estimate the impact of expected changes in farm product prices and factor costs reflecting the various biophysical, economic, and political sources of uncertainty. The impact of changes in product prices and factor costs were investigated separately for agropastoral farming systems. The experts were selected according to the following criteria: knowledge and experience in the field of agricultural production, and competence in conducting economic evaluations. This ensured that estimates predicted the development of factor costs and prices with reasonable accuracy (see Appendix 3). Experts were asked to estimate an increase or decrease in product prices and factor costs (e.g., animal price, wheat, diesel, fertilizers). Given the highly uncertain nature of the expected changes with Kyrgyzstan's accession to the EAEU, experts were asked to give the most likely price within a 3-year horizon. Data were collected via a structured questionnaire; each interview lasted 40-60 minutes. Furthermore, a group of 20 farmers of the original sample representing the full range of agropastoral farm characteristics in the Central Tien Shan study site were interviewed. This was done to conduct Monte Carlo simulations for static and dynamic scenarios and compare the results of both analyses. In section 5.4.3, the detailed description of survey-based modelling method is presented.

5.4 Data analysis

5.4.1 Descriptive statistics

Questionnaires completed on tablets using the ODK application facilitate downloading of data in Microsoft Excel format; data collected from different tablets were merged into one large Microsoft Excel data bank. Subsequently, questionnaires with missing values and errors were excluded and then the remaining quantitative data were processed and analyzed using MS Excel to generate descriptive trends and frequencies. Quantitative data collected from household surveys were processed and analyzed using the Statistical Package for Social Sciences (SPSS) version 21 program (IBM 2017). Selected variables related to farm characterization were classified into following categories to explore smallholder farm diversity in the study site through multivariate analysis: geographic characteristics of the area; agroecological and socio-economic parameters; land holdings and use; labour; livestock capacity and ownership; production inputs; and production methods. In addition to these categories for silvopastoral farming systems, in Jalal-Abad province, further categories were added, such as forest leasing and use and labour. Because farms in a given farming system may differ and are somewhat unique, they may have distinct decision-making processes and specific development constraints. Therefore, a classification in relatively homogenous groups of farms with similar characteristics (i.e., socio-economic situations, needs and objectives, and the extent of pasture and forest degradation and interlinked challenges) based on the results of comparative analyses to assess potential farming systems development pathways was used (Doppler 1992; Dunjana et al. 2018).

5.4.2 Typology construction

Two multivariate techniques: principal component analysis (PCA) and cluster analyses were employed sequentially for generating a typology of the farms, as used in similar studies (Köbrich et al. 2003; Tittonell et al. 2010; Guillem et al. 2012; Pacini et al. 2014; Chatterjee et al. 2015; Kuivanen et al. 2016; Namuyiga et al. 2022).

PCA was used to standardize variables and condense all the information from the original interrelated variables to a smaller set of factors called principal components (PC). Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett test of sphericity were conducted to check the suitability of the data for PCA assessment (KMO value 0.6 absolute minimum). Factors were rotated using the orthogonal Varimax method to subsume the correlated variables into a respective PC, which makes the pattern of loadings more pronounced and reveals simple structuring of variables into theoretically meaningful subdimensions. PCs with eigenvalues > 1.0 were selected and interpreted (Hair et al. 2006). Furthermore, correlated variables within a PC were represented by the variable with the highest loading coefficient (Dunjana et al. 2018). Finally, we performed correlation analysis using Pearson's correlation coefficient to test for relationships among the selected variables and eliminated one of the two strongly related variables to avoid double weighting of factors (Granato et al. 2018).

In the next stage, farms in Chuy and Naryn provinces were grouped by agglomerative hierarchical classification and the farms of Jalal-Abad province by *K*-means cluster analyses based on variables identified by PCA and Pearson's correlation matrix. Ward's method and the squared Euclidean distance were used in both analyses as metrics to establish clusters as proposed by Granato et al. (2018) and Santos et al. (2019). Subsequently, we used the independent samples t-test and analysis of variance (ANOVA) accordingly to compare means of independent groups to determine whether there was statistical evidence that the associated population means differed.

5.4.3 Farm income modelling using Monte-Carlo simulation method

Monte-Carlo simulation is a stochastic technique that involves using random numbers and probability distributions to simulate the different impacts of uncertain variables on the model outcomes (Liu et al. 2015). This method is the most used approach to explore uncertainty in the context of biophysical and micro- or macroeconomic research problems (Graveline et al. 2012). Several studies have used this method to assess the impacts of economic trend scenarios on farm income. For example, Kabura (2007) and März (1991) simulated product price changes and determined the effects these changes had on the stability of farm income in Kenya and Syria. Graveline et al. (2012) used Monte-Carlo simulation in combination with linear programming to predict farm income in two French regions based on different scenarios of water abstraction for irrigation and nitrate leaching into groundwater. Liu et al. (2015) simulated the economic costs and benefits at farm-household and regional scales and identified variables with the most influence on economic performance of climate resilience strategies. Lauwers et al. (2010) simulated income risk factors and volatility in capital return of organic agricultural activities on eight crops. Rauh et al. (2007) and Kroeber et al. (2007) explored economic risks in agricultural production of fuel wood and in biogas plants and demonstrated the impact of uncertainty variables on the economic performance of both production systems. The usual disadvantage of this method is that value allocation to each uncertainty variable is random and does not consider the interrelationship with other uncertainties. Thus, a large number of modes in the simulation output use unreal or unlikely combinations of the uncertainty variables (Rezaie et al. 2007).

We used the @Risk Monte-Carlo add-on for MS Excel v. 6.3.1 (Palisade Corporation 2016) to simulate the impact that expected changes in product prices and production, or factor costs had on net farm profit from animal and crop production for smallholders. We determined the expected changes in product prices and production costs induced by the accession of Kyrgyzstan to the EAEU through expert interviews described in section 5.3. Furthermore, we distinguished between static and dynamic scenarios in our simulations. The initial analyses were performed with fixed parameters assuming that the expected changes in prices and costs will not induce changes in production methods or land use by farmers (a scenario called 'first-order change only'). A second set of analyses was conducted to scrutinize the impact of such changes on farmer incomes ('second-order change') using the data on adaptation strategies. This captured the likely development trajectories of the farm production system. To obtain this information, a group of 20 farmers was interviewed (see section 5.3) . Comparing the results of both analyses was deemed suitable to further clarify the impact of Kyrgyzstan's accession to the EAEU on smallholder farmers.

We determined a triangular probability distribution for each uncertain independent variable by collecting information on the expected minimum, maximum, and most likely value (mode) for each input variable from expert interviews (Figure 6). A uniform distribution, which gave all values within the range of minimum and maximum an equal chance of occurrence, was used if a mode value was not given. We conducted 1000 Monte Carlo simulations to determine the probability distribution and cumulative distribution functions for net farm profit and related output variables, such as revenues and expenses of each production method, assets and profit margin, and on-farm income. The Latin hypercube sampling procedure was used. The sensitivity of simulated outputs to variations of the uncertain values was assessed by calculating the rank order correlation coefficient with @Risk, which was expressed in "Tornado" diagrams.

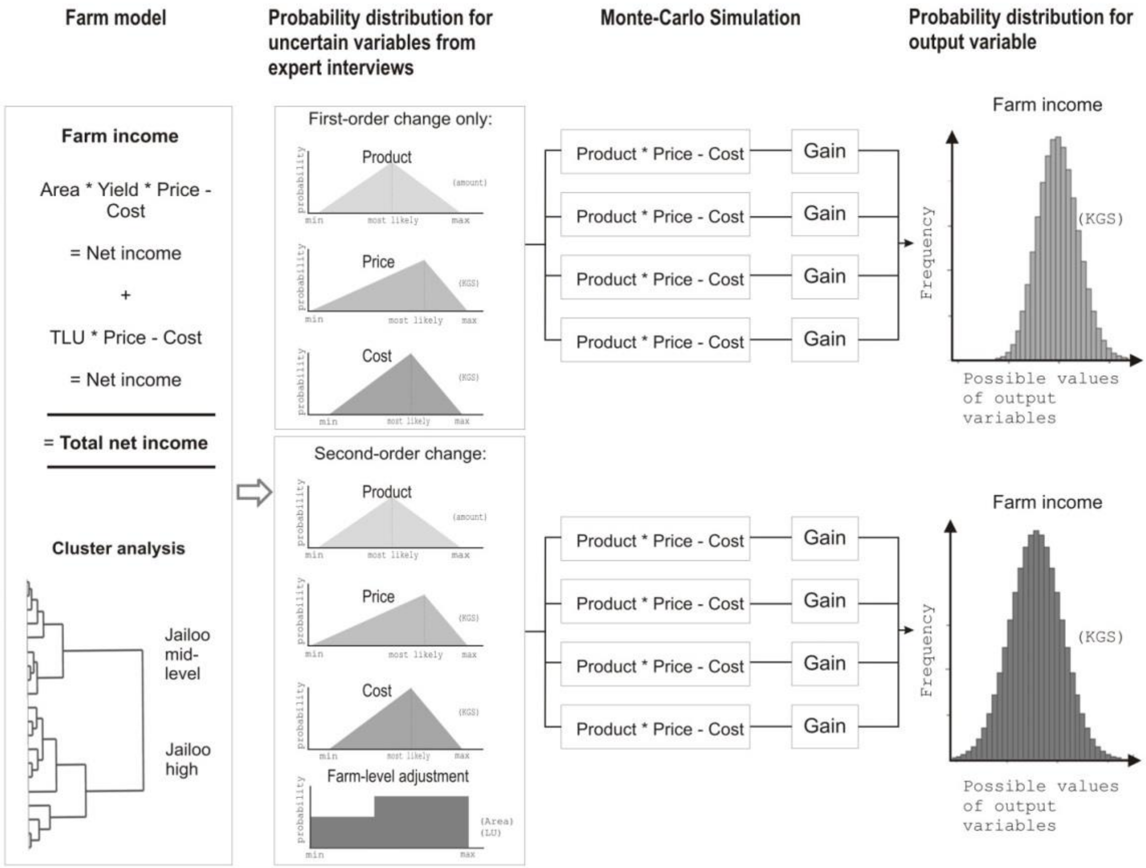


Figure 6 Illustration of the modelling approach pursued. Adapted from Azarov et al. (2019)

5.5 Calculation of gross margins and winter fodder availability

5.5.1 Gross margins in animal and crop production

We computed the gross margins (GM) to assess the farmers' operational performance in livestock and crop production. The GM was calculated as gross income/revenue minus direct variable costs. The higher the GM, the more money will be left towards paying for fixed costs, and hence maximizing the GM is equivalent to maximizing profit. This method helps to quantify farmers investments, operating costs, and outputs of their production, i.e., effectiveness of production techniques. Values were calculated based on actual farm gate prices. All feeding costs were included as variable costs, which also included payment for herders' services and fees for pasture use. Animal activities included their replacements, culling (price for old animals), animal mortality (loss of breeding, calves/lambs), and annual offspring. The costs for the feeding dairy cows, mares, sheep, and goats included fodder for offspring. In agropastoral farms, the calculation of gross margins in crop production involves computing them per hectare and then multiplying the result by the total size of the crop. The gross margin per hectare is determined by considering revenue from crop sales or market price and deducting variable production costs, including seeds, fertilizers, pesticides, labor, machinery, and fuel etc. This approach facilitates a comprehensive assessment of profitability. The incorporation of NTFPs into crop production within silvopastoral farms was motivated by the absence of arable lands in such farms (except forest meadows and home gardens). In certain regions, silvopastoral farms were able to acquire leasing rights for nearby forests. Consequently, these leaseholders were granted exclusive harvesting privileges for walnuts in these specific areas, while also actively engaging in forest conservation efforts and contributing to the seed bank maintained by the forest center.

5.5.2 Fodder energy value, digestibility and forage intake of animals

The quantity of feed obtained annually from different cropping systems was calculated by multiplying the number of hectares of each crop type by its respective yield. The amount of purchased feedstuff was added to the quantity obtained from farms. The feedstuff demands for the various types of animals were computed based on their gross energy (GE), which was converted into metabolizable energy (ME) in dry matter (DM) and used with varying efficiencies according to maintenance, growth, milk, gravidity, and motion expressed in megajoules (MJ/kg DM) (for dairy cows MJ NEL; net energy content for lactation). The average nutritional values (mid-quality) of certain fodder types were taken from the Fodder of USSR book (Tommea 1964), as well as from the German Agricultural Society's feeding Value Tables (DLG 1997). The feed requirements (energy and protein supply) for animals were taken from publications of the Bavarian Regional Office for Agriculture considering feeding norms for ruminants and horses according to live weight and daily fodder intake (LfL 2010, 2017) (Appendix 4).

The total livestock population of the interviewed households was converted to a livestock unit (LU). Conversion factors recommended by Government Decree No. 386 of 19 June 2009 (Isakov and Thorsson, 2015; Government of the Kyrgyz Republic 2010) were used. Therefore, a conversion factor of 0.20 was used for sheep and goats and a conversion factor of 0.8 for horses according to official recommendations. The DM requirement of an animal was calculated based on the daily DM requirement of 300 kg dual purpose cattle (equivalent to one LU) with an average maintenance requirement ranging from 7.5 – 10.3 kg DM per day and animal on average, depending on the quality and energy value of the feedstuff.

The feeding calendar was created to determine the annual winter feed balance, total livestock feed produced from different feed sources, total livestock units, and their winter maintenance requirement. The winter maintenance requirement of the animals was calculated and subtracted from the total livestock feed produced or purchased per year. If the amount of feed stored per year was above the maintenance requirement of the animals, feed exceeded the maintenance requirement, otherwise there was a deficiency of livestock feed in farm-households. The resulting feeding calendar provides information about the opportunities and gaps in feeding during the year, the condition of the animals showing gains or losses, and, most importantly, the grazing pressure on the available pasture in a given period of time presented in a figure. .

6. Results

This chapter elaborates the preconditions of agricultural production, general livelihoods such as study site borders, biophysical, and agroecological, and subsequently farming system development. As noted, data on smallholder farming systems were collected in different mountain regions of Kyrgyzstan at different times. The purpose of this design was to compare the agropastoral production systems common to the Central Tien Shan mountains with the dominantly silvopastoral systems of southwestern Kyrgyzstan. These areas also differed with regards to climate, elevation, and regulations that affected the use of available natural resources, as well as the status and development of resource degradation. Based on these aspects, the analyses conducted to differentiate mountain farm types focused conditionally into two sub-areas: southwestern and central Tien Shan mountains. The separate overview of general characteristics and conditions in the study sites is the basis for the selection of classification variables for these two sub-areas. Thus, the results of the farm classification using cluster analysis are presented separately for silvopastoral and agropastoral farms. Herein the results of the farm classifications are the basis for the comparative farming systems analyses.

6.1 Classification of farm populations in south-western Tien Shan mountain ranges (relevant to Aim 1)

6.1.1 Socio-economic characteristics of silvopastoral farm-households

This section is answering research question 1 about the prevalent farming systems in south-western Tien Shan mountains, research question 2 about methods to classify these farming systems.

Collection of NTFPs

Discussions with local forestry specialists, representatives of local government experts, and the farm households themselves were conducted to obtain general information on local livelihoods. These discussions revealed that walnut-fruit forests play an important role in the rural economy. In these forests, local households are mainly involved in the collection of walnuts (*Juglans regia*) and other edible NTFPs such as berries (*Rubus occidentalis* L., *Rubus fruticosus* L., *Berberis vulgaris* L.), mushrooms (*Morchella* sp.), wild garlic *Allium sativum* L., wild apples (*M. sieversii, M. niedzwetzkyana*), wild rosehips (*Rosa* sp.), wild plum (*Prunus sogdiana* Vassilcz.), and hawthorn fruits for medicinal purposes (*Crataegus knorringiana* Pojark. and *C. pontica* K.Koch). The rules of NTFP collection are regulated by local forestry units or nature reserves and differed from village to village because of the status of the forests where the farming population lived (see section 5.1.1). For instance, among all NTFPs, walnuts were assessed as the most important forest product by farmers and represented the highest values in Kara-Alma and Arkyt villages, while wild raspberries were the most valuable in Kashka-Suu village since there were no walnut forests in this village. Wild apples and wild pears were evaluated by farmers as the next most important forest products in Kara-Alma village only, while mushrooms were assessed as another highly valued NTFP in all villages. In Kara-Alma, the importance of wild apples and pears was very important when there were limited opportunities to harvest walnuts. Although almost all of the surveyed households collected various NTFPs in some quantities; about 70% of households collected NTFPs specifically for sale, keeping the remaining portion for their own consumption. This indicated that collection of NTFPs was mostly market oriented (Table 1).

Table 1 List of major NTFPs for sale and family consumption

NTFP	Latin name	For sale	Family consumption	Processing**
Walnut*	*Juglans regia*	✓	✓	×
Wild apples*	*Malus niedzwetzkyana*†	✓	×	×
	Malus sieversii†	✓	×	×
Wild pear*	*Pyrus asiae-mediae*	✓	×	×
	Pyrus turcomanica†	✓	×	×
Wild raspberry*	*Rubus occidentalis*	✓	✓	✓
	Rubus fruticosus	✓	✓	✓
Barberry	*Berberis vulgaris*	✓	✓	×
Rosehip	*Rosa* sp.	✓	✓	×
Mushroom	*Morchella* sp.	✓	✓	×
Hawthorn	*Crataegus knorringiana*†	×	✓	×
	Crataegus pontica†	×	✓	×
Plum*	*Prunus sogdiana*†	✓	✓	×
Wild garlic	*Allium sativum*	✓	✓	×

*The proportion of sales exceeds 90% of the total collected NTFPs; ** It refers to the processing of NTFPs only for family consumption (e.g., jams, drying). NTFP – non-timber forest product; † endangered species.

Animal husbandry

Livestock was another significant source of income in silvopastoral households and provided a cash savings account for farmers. Local steppe cattle, horse breeds suited for milk and meat, and fat-tailed sheep suited for meat production dominated. Households had an average herd of 6.5 LU, and a typical herd consisted of cattle, horses, and a small number of sheep (very rarely goats). Average dairy milk productivity was 500 kg for a cows' lactation cycle and $\approx$150 kg carcass weight per cow. Local experts assessed these values as mediocre given that the farm production system was characterized as low input and low output. Animals were raised mainly for sale (26% of herd) as the proportion of animals annually slaughtered for family consumption was negligible (about 2% of herd). Sheep and goats were mainly slaughtered for family consumption, while cattle and horses were only slaughtered on rare occasions, such as weddings and funerals, when many villagers were invited to such traditional events. Farmers preferred to keep more cattle and horses rather than sheep and goats, as the latter were considered unsuitable for grazing in the vast forested areas due to the frequent loss of sheep. Farmers also preferred to keep sheep rather than goats because goats harm young fruit trees and the market price of goats was much lower than sheep with the same upkeep cost per animal. Unlike sheep and goats, cattle and horses are self-sufficient and do not require constant supervision.

Crop cultivation and other farm income sources

Farm households in Kara-Alma and Arkyt villages did not have arable lands and even when such land was available (e.g., in Kashka-Suu village), these were not cultivated due to the lack of irrigation systems. As such, cultivation occurred mainly on small plots of land (kitchen gardens) ranging from 0.05 to 0.3 ha in size. While mainly vegetables were grown largely for subsistence consumption, there were also some fruit trees (e.g., plums, apples) in these kitchen gardens. Most farmers have forest meadows that are informally allocated to households in the 1990's or earlier, where a small part of winter fodder (mainly hay) was collected. In Kara-Alma village, hay yields were low because the meadows were not hedged, and animals grazed in these meadows. Revenues from sale of cultivated products, such as plums and vegetables from kitchen gardens, were negligible, while the sale of meadow hay was not observed in any farm-household (fed entirely to owner's herds). In contrast, the sale of processed dairy products was a significant part of farm income, with more than 90% produced for sale, indicating the importance of keeping dairy cows. In all villages, honey production has developed in recent years, and the number of beekeepers was increasing. Of the surveyed households, about 10% had apiaries.

Income sources from non-agricultural activities

The income derived from off-farm activities substantially contributed on average to total family income. However, opportunities for non-agricultural employment and off-farm business opportunities were generally low in all three villages. External migration and remittances (mostly from Russia) played a huge role in the household economy and accounted for almost half of all off-farm income. According to farmers and local experts, migration has become an integral part of village life and has intensified over the last decade, mainly to compensate for the erratic walnut yields in Kara-Alma and Arkyt, while in Kashka-Suu mostly due to low opportunities for non-agricultural employment. Pensions and salaries from public institutions represented the second most important source of total non-agricultural income, while the income from self-employment/private business (e.g., shops, taxi drivers, tourism) and employment in the private sector was third in importance in total off-farm income. Tourism was booming, particularly in two villages, Arkyt and Kashka-Suu, because of the natural attractions. Villagers tried to capitalize on increasing tourism by selling farm produce or providing services to tourists.

Agricultural markets

The markets (in fact souks or 'bazaars' in Kyrg.) where mainly livestock and crops are sold are found at distances of 12 to 50 km away from farms and are relatively easily accessible by transport facilities. Farmers mainly sold livestock in these bazaars; these are open daily, but the selling and buying of livestock was done only on weekends depending on the village and region. Farmers also sometimes bought winter fodder such as grain and hay at these markets. The bulk of the purchased hay came from farms located in other regions of the country, primarily from large-scale specialized farmers in the lower Chui, Talas, and Ferghana valleys. Direct sales of NTFPs at these markets were almost non-existent. As in the villages, local resellers bought not only forest products, but also dairy products and crop produce from the yard. In recent years, the number of private hay sellers bringing fodder directly to the villages has increased. Some farmers bartered with such sellers, i.e., hay in exchange for NTFPs. In each village there were stores where food and other household goods could be purchased.

Farmers' perceptions of forest degradation and its causes

Farm households, lacking substantial arable land, purchased over 90% of winter livestock fodder. Most farmers found their total stored winter feedstuff inadequate. Due to the lack of pastures, local silvopastoral households grazed their herds in designated forest lands, although grazing often occurred where it was forbidden. The pasturing period, up to 12 months, aimed primarily to reduce winter fodder needs. Fodder shortage during winter led to emaciated animals, forcing farmers to graze in forests, feeding on plant remains like branches and tree bark (e.g., wild apple). Growing livestock numbers worsen grazing impacts, doubling in the past decade, as per local nature reserve and forestry experts. Illegal logging ceased, occurring in the 1990s to early 2000s during a transitional and economically declining period. The perception of degradation was discussed controversially, for example, more than half of the surveyed farmers do not see much degradation in the forests, comparing the condition of the forests in the 1990s, while at the same time reporting that the forests have become thinner and old, and there is increasingly less in the forests.

6.1.2 Development of farm typology for silvopastoral farm-households

Descriptive statistics for classification variables

As already described in the literature review and the methodological section of this study, classification of farming systems can be carried out with different purposes, and it is obvious that results of clustering procedures were heavily influenced by the selection of input variables. The classification results can therefore only be valuable with respect to their purposes and uses. The purpose of classification in this study is to find farm classes that are homogenous in their resource availability and use, production systems, socio-economic performance, needs, as well as development constraints, which are related to pasture and other resource degradation and management. Therefore, classification parameters that reflect the agroecological conditions, farm-households' resource base and its use, agricultural production systems, as well as off-farm activities were selected. Eighteen classification variables were selected that show mostly high variations, which in turn are one of the preconditions for satisfactory classification of farm populations (Table 2).

Table 2 Quantitative variables from questionnaires used in PCA (n = 220)

#	Variables	Minimum	Maximum	Mean	Std. Dev.
1	Village/farm elevation, m above sea level	1255.00	1505.00	1414.00	92.80
2	Distance to market (km)	11.00	55.00	33.60	16.00
3	Annual walnut revenues (USD[1])	0.00	10628.20	2104.80	2328.95
4	Annual wild apple revenues (USD[1])	0.00	531.40	78.91	116.91
5	Annual other NTFPs revenues (USD[1])	0.00	1003.80	183.71	216.37
6	Days for walnut collection (day/year)	0.00	120.00	44.94	36.18
7	Days for NTFP collection (day/year)	0.00	59.04	15.66	16.61
8	Transportation costs of all NTFP (USD[1])	0.00	200.05	101.32	46.80
9	Total herd size (LU[2])	0.00	20.10	6.53	4.38
10	Number of cattle (LU[2])	0.00	13.00	4.11	2.53
11	Number of horses (LU[2])	0.00	12.30	1.87	2.34
12	Average winter fodder expenses (USD[1])	0.00	3309.90	818.41	674.60
13	Other farm income[3] (USD[1]/year)	0.00	3678.60	617.36	1255.77
14	Revenues from dairy products (USD[1])	0.00	2952.30	355.44	547.58
15	Total off-farm income (USD[1])	0.00	6140.80	2087.25	1536.09
16	Total number of migrants (person)	0.00	3.03	0.64	0.60
17	Size of arable land (ha)	0.00	0.23	0.03	0.06
18	Size of leased forest (ha)	0.00	20.07	3.32	4.20

[1]In USD: average exchange rate in July 2021, 1.00 USD = 84.68 Kyrgyz som (adapted from www.oanda.com).
[2]Livestock unit, one LU corresponds to one cattle, 0.8 horses, or 5 sheep/goats.
[3]Other farm income includes income from the sale of dairy products, crop products and apiaries.
NTFP – non-timber forest product.

Identification of key classification variables

As already mentioned, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett test of sphericity were conducted to check the suitability of the selected variables for PCA assessment (KMO value 0.6 absolute minimum). A 'middling' KMO value (0.719) (Kaiser & Rice 1974; Shrestha 2021) and a significant Bartlett's test of sphericity (level of 0.00) suggest that 18 classification variables are suitable for further analysis using PCA (Table 3).

Table 3 Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett test of sphericity

Statistical Tests		
Kaiser-Meyer-Olkin value		0.719
Bartlett's Test of Sphericity	Approx. Chi-Square	3090.000
	df	153.000
	Sig.	0.000

Kaiser-Meyer-Olkin value must be greater than 0.6.
Bartlett's Test (df: Degree of freedom, Sig: Statistical significance, *p<0.00*).

Kaiser's criterion is a powerful factor retention method because it is based on distribution theory of eigenvalues, shows good performance, is easily visualized, and computed, and is useful for exploratory factor analysis or PCA. Table 4 shows the rotated factor matrix of independent variables with factor loadings. A common rule is to extract all the factors with Eigenvalues of 1.0 or more and the results show that five PCs had eigenvalues satisfying this criterion. The first component explains 26.0% of the variability, the components 2, 3, 4 and 5 explain 17.3%, 14.4%, 10.4% and 8.1% of the variability, respectively. Together the components explained 76.3% of the total variability.

Table 4 Principal components with eigenvalues above Kaiser's criterion of >1

Total Variance Explained[1]						
	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.031	27.952	27.952	4.688	26.046	26.046
2	3.301	18.337	46.289	3.112	17.290	43.337
3	2.675	14.860	61.149	2.603	14.459	57.796
4	1.371	7.616	68.765	1.871	10.394	68.190
5	1.352	7.513	76.278	1.456	8.089	76.278
6	0.869	4.828	81.106			
7	0.648	3.602	84.708			
8	0.600	3.334	88.042			
9	0.389	2.160	90.202			
10	0.376	2.086	92.288			
11	0.350	1.943	94.232			
12	0.287	1.592	95.823			
13	0.239	1.326	97.150			
14	0.199	1.105	98.254			
15	0.146	0.809	99.064			
16	0.068	0.377	99.441			
17	0.058	0.323	99.764			
18	0.043	0.236	100.000			

[1]Extraction Method: Principal Component Analysis.

Rotated factor (Varimax) matrix of independent variables with differential factor loadings is also given in Table 5. Within each PC, variables with factor loadings >0.5 were retained, while those with loading factors <0.5 were discarded. A closer look at each column helps to define each component according to the strongly associated variables. PC1 contained seemingly different variables, including geographic characteristics (distance to market) and agricultural resources (significant size of arable land). The correlated variables of PC1 are related to farmers from Arkyt and Kara-Alma villages, as they had the highest income from harvesting walnuts and wild apples, thus the highest time expenditure for collection and transportation costs of these forest products, and farmers in these villages had leased forests and at the same time no arable lands. Also, these villages are further away from markets. PC2 explicitly includes livestock production variables: herd size, number of horses and cattle, and total value of winter fodder. PC3 consists of variables that are related to farmers from Kashka-Suu village, where the elevation was the lowest among the other villages and the collection of NTFPs other than walnuts was the highest due to the lack of walnut forests. . PC4 covers all other income of the farm from the sale of dairy products, crop products, honey (excluding income from the sale of animals). PC5 covers variables related to off-farm income, such as total off-farm income, number of migrants who contributed to family income through remittances.

Table 5 Rotated component matrix of classification variables with factor loadings grouped in five principal components (PCs)

	Principal Component[1]				
Variables	1	2	3	4	5
Distance to market	0.922				
Annual walnut revenues	0.859				
Days for walnut collection	0.848				
Size of leased forest	0.848				
Size of arable land	−0.793				
Transportation costs of all NTFP	0.713				
Annual wild apple revenues	0.624		0.537		
Total herd size		0.910			
Average winter fodder expenses		0.860			
Number of horses		0.794			
Number of cattle		0.730			
Annual other NTFPs revenues			0.908		
Days for NTFP collection (day/year)			0.906		
Village/farm elevation			0.557		
Total other farm income				0.781	
Revenues from dairy products				0.767	
Total off-farm income					0.828
Total number of migrants					0.814

[1]five components extracted using orthogonal Varimax rotation method with Kaiser Normalization.
Associated variables with factor loadings >0.5 are allocated to the respective principal component.
NTFP – non-timber forest product.

Cluster profiles of silvopastoral farming systems

High correlations disturb the classification and can lead to unwanted distortion and incorrect clustering. A high correlation between two variables means that one of the variables accounts for most of the variability of the other variable. Using both variables is equivalent to giving a double weight to one variable. Therefore, before conducting a cluster analysis using the *K*-means method, we tested the classification variables derived from the PCA for correlation. The variables within a PC with the highest loading coefficients and greatest standard deviations, namely ‘annual walnut revenues’, 'total herd size’, ‘annual other NTFPs revenues’, ‘other farm income’ and ‘total off-farm income’ were tested for correlations again. Within PC1 the variable ‘distance to market’ which has a highest loading factor was not taken because it had low standard deviation (cf. Table 2). Because the selected variable 'total herd size’ of PC2 was correlated with the selected classification variables of PC4 ‘total other farm income’ and ‘revenues from dairy products’ due to larger dairy herd size in the farm-household and the greater marketing of dairy products. Since the variable ‘total other farm income already includes the variable ‘revenues from dairy products’, and its share in ‘total farm income’ was highest, this variable was correlated with ‘total herd size as well. Therefore, both PC4 variables were removed (i.e., ‘other farm income’ and ‘revenues from dairy products’). Table 6 shows four remaining variables that were not correlated with each other and used further in the cluster analysis.

Table 6 Non-collinear variables used in *K*-means cluster analysis

Variables		Walnut revenues	Off-farm income	Herd size	Other NTFP revenues
Walnut revenues	Pearson Correlation	1.00	-0.131	0.111	0.081
	Sig. (2-tailed)[1]		0.053	0.1	0.229
	N	*220*	*220*	*220*	*220*
Off-farm income	Pearson Correlation	-0.131	1.00	0.13	-0.091
	Sig. (2-tailed)	0.053		0.055	0.18
	N	*220*	*220*	*220*	*220*
Herd size	Pearson Correlation	0.111	0.13	1.00	0.072
	Sig. (2-tailed)	0.1	0.055		0.285
	N	*220*	*220*	*220*	*220*
Other NTFP revenues	Pearson Correlation	0.081	-0.091	0.072	1.00
	Sig. (2-tailed)	0.229	0.18	0.285	
	N	*220*	*220*	*220*	*220*

The Sig. (2-Tailed) values are >0.05 indicating no statistically significant correlations among variables. NTFP – non-timber forest product

Three clusters were generated by the *K*-means method corresponding to three different types of silvopastoral farming systems (Figure 7). Three clusters of farming systems were generated based on a multivariate analysis as the prevalent systems in the south-western Tien Shan study site:

– Cluster I: ***high forest product dependent*** silvopastoral farming system (HFD) with higher NTFP income, medium-sized livestock herds, and low off-farm income.

– Cluster II: ***middle forest product dependent*** silvopastoral farming system (MFD) with moderate NTFP income, large livestock herds, and high off-farm income.

– Cluster III: ***low forest product dependent*** silvopastoral farming systems (LFD) with low NTFP income, small livestock herds, and moderate off-farm income.

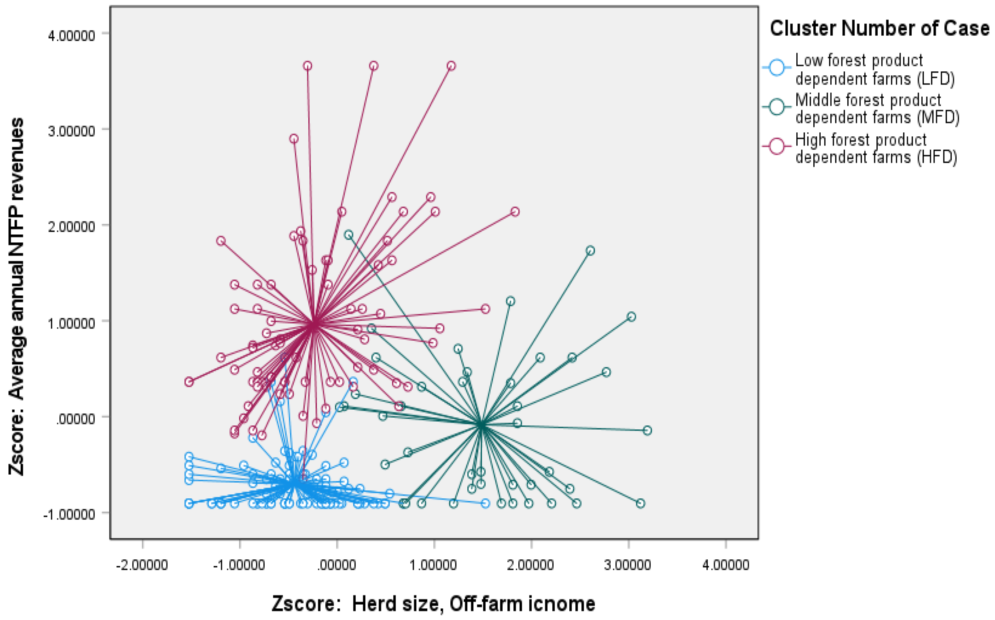


Figure 7 Distribution of farms according to the four final classification variables (the arrows represent variables that correlate strongly with each respective principal component)

These systems show distinctive differences in regard to their classification parameters (Table 7). All variables were subjected to one-way analysis of variance (one-way ANOVA) to identify significant differences among variables and subsequently farm types. All the selected classification variables showed significant differences among classes (Appendix 5).

High forest product dependent farms (HFD)

These farm-households are the second largest cluster and represent 35% of the surveyed farms. Farms with a large annual income from collecting and selling forest products (4602 USD), practicing silvopastoralism with an average herd of 5.48 LU and a total value of 3826 USD were grouped into this cluster. Farm-households in this group have leased forests because farmers in this group were entirely from the village of Kara-Alma, where leasing forests, primarily for walnut collection, was allowed. This cluster is also characterized by the lowest income from off-farm activities (1429 USD) and the greatest share from remittances (61%) compared to other clusters.

Middle forest product dependent farms (MFD)

These farm-households are the smallest cluster representing 19% of all surveyed farm-households. The cluster is classified as farms with moderate annual NTFP income of 1911 USD and the largest livestock herds (12.8 LU), with an average total value of 8010 USD. Farmers in this cluster were mainly from Arkyt, with a smaller amount from Kara-Alma village, who did not have leased forest land. Compared to first type, the smaller revenues from walnut collection in Arkyt village were attributed to collection limitations for Arkyt farmers and the lack of leased forests for Kara-Alma farmers. Farmers had the highest income from off-farm activities among all clusters (on average, 3231 USD per year). The share of remittances was also dominant compared to other off-farm income sources–51% of total off-farm income.

Low forest product dependent farms (LFD)

These farms-households represent 46% of all surveyed farms and is the largest of the three clusters. This cluster included farmers mainly from Kashka-Suu and fewer from Arkyt and Kara-Alma villages. Farmers are characterized by low NTFP income (604 USD per annum), small herd size (4.63 LU) and moderate off-farm income (2114 USD per annum on average). Although remittances dominated total off-farm income (37%), this share was the smallest among the three clusters.

Table 7 Characteristics of the silvopastoral farming systems in south-western Tien Shan according to their classification parameters

	Clusters/Types of farms		
Variables	**HFD** (n = 77)	**MFD** (n = 42)	**LFD** (n = 101)
Average annual walnut revenues* (USD†)	4352	1911	472
Average annual NTFPs revenues* (USD†)	250	186	132
Herd size* (livestock units)	5.48	12.83	4.63
Off-farm income* (USD†)	1429	3231	2114

*Statistical significance, $p < 0.05$.
†In USD: average exchange rate in July 2021, 1.00 USD = 84.68 Kyrgyz som (adapted from www.oanda.com).
HFD - high forest product dependent farms; **MFD** – middle forest product dependent farms; **LFD** - low forest product dependent farms; NTFPs – non-timber forest products.

In following subchapters, detailed analyses of available resources, their use, farm management features and performance, as well as the role of non-agricultural activities of each type of farming systems are presented. Of particular interest are the resource use patterns of both NTFP collection and grazing practices in forest pastures and the issues associated with these activities.

6.1.3 Resource management and socio-economic performance of silvopastoral farms

This section is answering research questions 3 about the characteristics of the farming systems and how can they be differentiated based on resource allocation, socio-economic performance, agricultural production methods and off-farm income sources.

6.1.3.1 Human resources

Family labour resources are analyzed here in the context of the family member's characteristics and available labour capacities, seasonality, and economy. Special attention is paid to human resources, i.e., family labour in terms of their inputs in agricultural production, in NTFP harvesting, and off-farm activities and their contributions to family income.

The ages of the family heads varied within and among farming systems and ranged on average from 54 (HFD) and 58 years (MFD) (Table 8). The share of the interviews with female family heads was in HFD 11%, while in MFD and LFD, 5% and 9%, respectively. The average family size in LFD was smallest (between 5.5 and 6.6) and statistically significantly different from the other two clusters. Most of the families in each farming system (especially in HFD and MFD) were extended families living in the same household (most often parents and their children including spouses and grandchildren). This would explain the fact that the number of adult family members prevailed.

The available labour resources were engaged in different ways by different farming systems. Most intensively, the available labour force in HFD and MFD was engaged primarily in the harvesting of NTFPs (mainly walnuts), which required all available labour in the family during the harvest season (late summer to late autumn). For instance, the duration of the walnut harvest in HFD and MFD was the longest, 70 and 54 days respectively, with almost all family members involved in the harvesting. In contrast, LFD farmers spent much less time (21 days) harvesting walnuts and the harvesting was conducted by male family members hired in a neighbouring village where walnut forests were available. Much less time was spent on collecting other NTFPs compared to walnuts in all groups, although LFD farmers collected wild raspberries by all family members, while in most cases male family members in HFD and MFD collected other NTFPs.

Table 8 Labour resources and labour input in various family activities in south-western Tien Shan mountains

	Clusters/Types of farms		
	HFD (*n* = 77)	**MFD** (*n* = 42)	**LFD** (*n* = 101)
Family size, persons	6.62	6.64	5.48
(Std. dev.)	*(1.95)*	*(1.44)*	*(2.00)*
Male child (0-10)	0.83	0.86	0.85
Male child (11-17)|0,5|LF	0.65	0.69	0.45
Men >18/|1,0|LF	1.83	1.98	1.43
Female child (0-10	0.90	0.81	0.72
Female child (11-17)/|0,5|LF	0.61	0.55	0.52
Women >18 |1,0|LF	1.79	1.75	1.54

	Clusters/Types of farms		
	HFD (*n* = 77)	**MFD** (*n* = 42)	**LFD** (*n* = 101)
Total available labour force (LF)	4.25	4.35	3.46
Walnut collection, day/year	70.30	54.30	21.40
(Std. dev.)	*(22.70)*	*(35.50)*	*(28.80)*
Collection of other NTFPs, day/year	21.60	15.10	11.30
(Std. dev.)	*(15.80)*	*(13.60)*	*(1.50)*
Family members with off-farm income	0.78	1.36	1.53
(Std. dev)	*(0.86)*	*(1.13)*	*(1.01)*
Number of migrants	0.50	0.69	0.67
(Std. dev.)	*(0.67)*	*(0.46)*	*(0.57)*

HFD - high forest product dependent farms; **MFD** – middle forest product dependent farms; **LFD** - low forest product dependent farms; LF **–** labour force; NTFP – non-timber forest product.

Off-farm employment was also another important activity where inputs of human resources were required, particularly in LFD and MFD, but unlike NTFP collection it was not seasonal, but more continuous requiring the constant engagement of more than one adult family member in these farming systems. In HFD, involvement in off-farm activities was the lowest among the clusters. In the agricultural sector, the involvement of family labour in livestock production was dominant as crop production only took place in home gardens and meadows (hay collection) and the input of labour increased in summer. The duration of work in gardens was short, not more than an hour a day, and was mainly done by female members of the family, while hay harvesting from meadows was the work of men. As a rule, hay was cut by hand for a few days and brought in by truck, less often by horse-drawn cart. Here it should be noted that meadow mowing was done in MFDs and LFDs, while in HFD the number of farmers mowing hay from forest meadows was negligible because meadows were not fenced, and animals grazed in these meadows. In a year, farmers mowed grass only once. In animal husbandry, feeding, milking dairy cows, and grazing engaged family labour for generally a couple of hours a day regardless of the season and herd size in all clusters.

6.1.3.2 Land and forest resources

All interviewed farmers had kitchen gardens, the largest sizes were in HFD (0.14 ha) and LFD (0.23 ha), while in MFD the average size of kitchen gardens was the smallest (0.09 ha) (Table 9). These gardens were mainly used to grow vegetables and fruit trees, mostly for their own consumption. Only LFD farmers had arable land as such, but it was fallow due to lack of irrigation systems. Leased forests were available only to HFD farmers, with an average size of 7.2 ha. Forest meadows were available for all, but their average size was highest for MFD and LFD farmers; moreover, almost 90% of the farmers in both groups harvested hay. In contrast, HFD farmers had on average the smallest meadows and more than 90% of the farmers in this group did not harvest hay.

The calculation of pasture area per farm was not possible, according to workers of the local administrations, specially allocated land for grazing in recent years is under severe pressure as the number of livestock increases every year in all villages. No clear measures to determine the carrying capacity of the allocated forest pastures were available in any village. The situation is further complicated because farmers conceal the actual number of livestock.

Table 9 Forest and land resources of farm-households in south-western Tien Shan mountains

	Clusters/Types of farms		
	HFD (*n* = 77)	**MFD** (*n* = 42)	**LFD** (*n* = 101)
Leased forest (ha)	7.20	0.00	0.00
Arable land (ha)	0.00	0.00	0.12
Kitchen garden (ha	0.14	0.09	0.23
Meadow (ha)	0.10	0.50	0.60

HFD - high forest product dependent farms; **MFD** – middle forest product dependent farms; **LFD** - low forest product dependent farms.

6.1.3.3 Economic output of NTFPs collection

The main costs in the collection of walnuts and wild apples were the transport costs from the forest to the farmyard for HFD and MFD farmers. In HFD, in addition to these costs there were the costs of hiring collectors (from the village or neighbouring villages) who were paid 10-12 USD per day or gave them half of the walnut crop they harvested. The collection of other NTFPs did not incur any external costs. Family labour was not included as expenditure because of the overall low employment rate in all villages. Thus, the share of all expenditures from NTFP collection was 9%, 4% and 2% of all revenues, for HFD, MFD and LFD farmers, respectively.

HFD farms had largest annual net income from collecting and selling forest products (4188 USD). Farm-households in this group leased forests with an average area of 7.2 ha. It is not surprising that the farmers in this group were entirely from the village of Kara-Alma, where leasing forests, primarily for walnut collection, was allowed. Walnut harvesting income dominated in this farming system. There were no official restrictions for farmers in this group to collect them. Farmers tried to harvest walnuts cleanly from their rented plots, as other residents could also harvest walnuts secretly. The level of income from the collection of other NTFPs (i.e., excluding walnuts) depended on the availability of labour and transport capacity (including horses) on the farm. About 15% of farmers in this cluster lacked labour and did not collect other NTFPs, while 64% of farmers who collected other NTFPs joined with other farms to collect and sell NTFPs (e.g., wild apples). The average annual income from other NTFPs was 227 USD (Figure 8), with the collection and sale of wild apples accounting for 69% of other NTFPs. Mushrooms (12%), wild onions (9%), rosehips (7%), and red and yellow hawthorns (4%) accounted for the remainder of the collection and sales from other NTFPs. Hiring additional labour for walnut collection occurred only in HFD; on average, 45% of surveyed farmers hired people during the last three years. However, during a good walnut harvest, this increased to more than 70%.

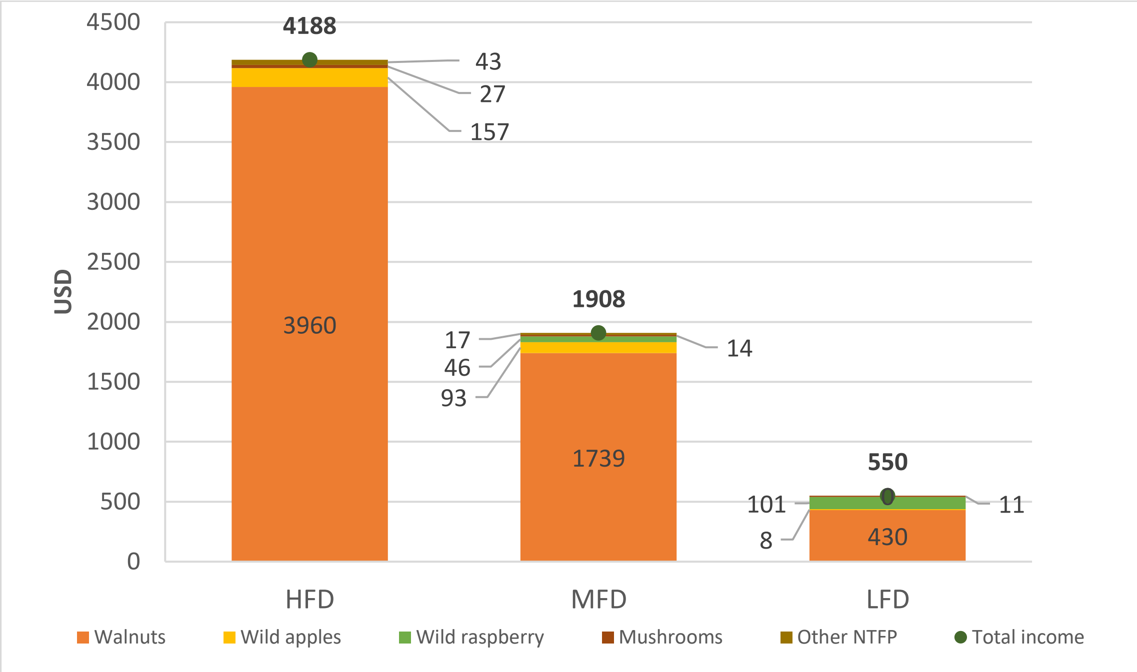


Figure 8 Income contibutions from collecting NTFPs of high, middle and low forest dependent farms (HFD, MFD, LFD) in south-western Tien Shan

MFD had moderate annual NTFP net income of 1908 USD. Farmers in this cluster were mainly from Arkyt, with a smaller amount from Kara-Alma village who did not have leased forest land. Compared to , HFD, the smaller revenues from walnut collection in Arkyt village are attributed to official restrictions NTFP collection and the lack of leased forests in Kara-Alma. Income from walnut harvesting also dominated in this farming system. As there were no leased forests in this farming system, farmers were only allowed to harvest walnuts in precisely defined areas (mostly near the villages) which were defined by the nature reserve. In fact, farmers would go into the forest and harvest walnuts wherever they found it and even in forbidden forest areas. There was not an informal division of forest plots within the MFD, and the collection of walnuts was done in an opportunistic manner, i.e., those who saw it first would take it. The annual share of revenues from other NTFP collection (excluding walnuts) was 169 USD on average. Similar to the HFD farm system, wild apple revenues dominated and accounted for 55% of total other NTFP revenues, while mushroom and wild onion revenues ac-counted for 27% and 8%, respectively. NTFPs such as hawthorn and rosehips accounted for the remaining 10% of other NTFP revenues. Most of the NTFPs were collected by farmers from Kara-Alma village, while Arkyt farmers collected only mushrooms. LFD included farmers mainly from Kashka-Suu and fewer from Arkyt village characterized by low NTFP income (604 USD per annum). Annual income from other NTFPs was the least among all clusters (120 USD), likely due to limitations and restrictions on the collection and because no walnut forests existed in Kashka-Suu village. Furthermore, only a few farm-households were hired to collect walnuts in a neighboring forest preserve where it was allowed. In Arkyt village, the small walnut revenues were attributed to the lack of labour resources. Other NTFP income was dominated by wild raspberries (89%), while the contribution from selling wild apples and mushrooms constituted only 1% and 10% of other NTFP income, respectively. It is worth noting that walnuts, wild apples, and wild raspberries, which had the highest contribution to NTFP income, were collected exclusively for sale in all types of farming systems because more than 95% of these forest products were sold. Other forest products such as mushrooms, hawthorn, wild onions had the smallest and insignificant contribution to the total NTFP income, most of which was destined for family consumption. NTFPs were sold in the vast majority of cases to resellers who came to the villages. Sales of processed NTFPs were not observed in any group of farming systems. In general, it should be said that farmers harvested those NTFPs that were in demand by resellers, otherwise they harvested NTFPs in small quantities for family consumption (barberry, rosehip, hawthorn). For example, in MFD and LFD, farmers tried to collect barberry, hawthorn and rosehip for sale, but there was no demand for such products from resellers. Moreover, there was a total or partial ban on the collection of most NTFPs except for some, for example LFD farmers were only allowed to collect wild raspberries, while MFD farmers were only allowed to collect walnuts in certain parts of the forest (mostly close to the village), but farmers in this group collected walnuts anywhere they were found.

6.1.3.4 Non-agricultural activities and off-farm income

Non-agricultural activities were an integral part of the livelihoods of all farming systems and contributed a significant portion of the family income. Figure 9 shows the total income from off-farm activities and the contributions from each type of off-farm source of income. HFD is characterized by the lowest income from off-farm activities of 1429 USD while MFD farmers had the highest income from off-farm activities among all clusters on average, 3231 USD per year as well as the greatest share from remittances (61%) compared to other clusters. Farmers in the LFD farming system obtained moderate income from non-agricultural employment – an average of 2114 USD per year. Notably, remittances were predominant in all farming systems. In HFD and MFD farms, remittances decreased in years when there were good walnut harvests with family members typically returning to their villages and helping with walnut harvesting and staying home for extended periods. According to the farmers of these groups, in bad harvest years migration both internally and externally increased to compensate for lost income from NTFPs. In contrast to these two farming systems, for LFD farmers, remittances were constant and have been increasing in recent years due to generally low employment opportunities in villages. The main remittances came from Russia (80%), the remainder (20%) from countries like Turkey, South Korea, Eastern European countries, and, less frequently, from USA. Remittances were mainly (75-84%) transferred by male family members.

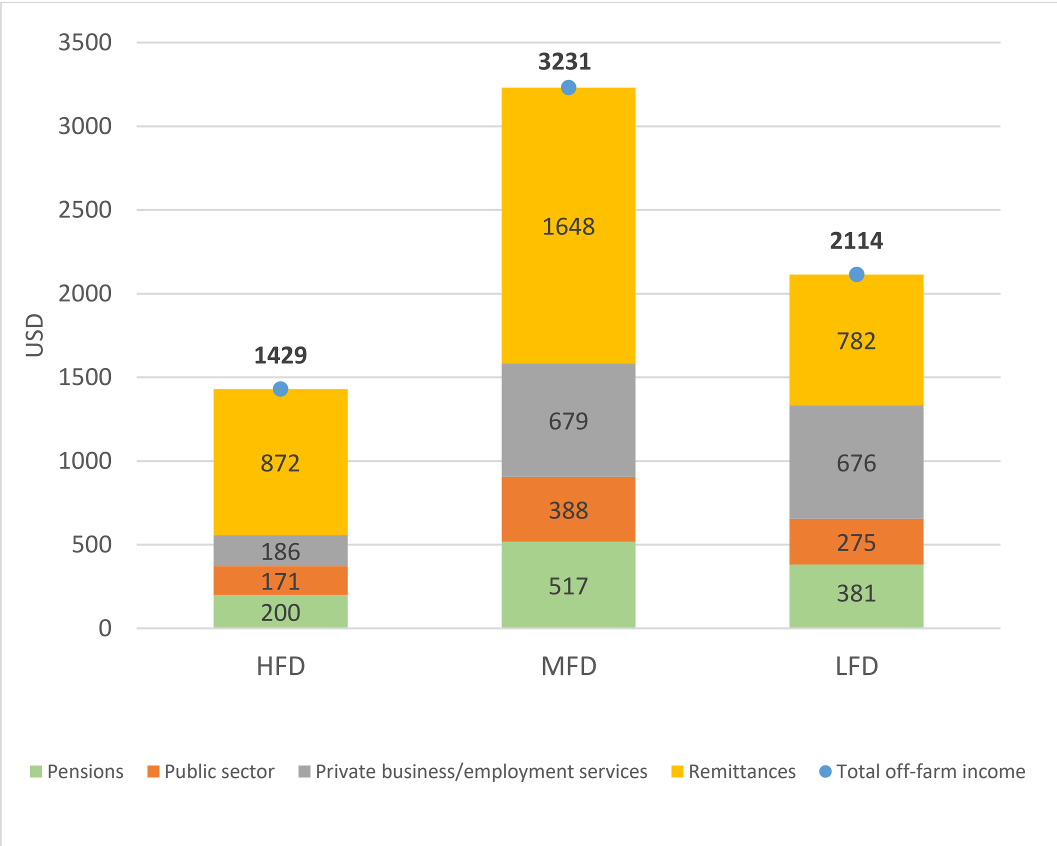


Figure 9 Income contributions from different off-farm activities of high, middle and low forest dependent farms (HFD, MFD, LFD) in south-western Tien Shan mountains

Pensions and the public sector were also important, together accounting for 26%, 28% and 31% of total off-farm income in HFD, MFD and LFD, respectively. Income from the public sector and pensions of female and male family members were almost equally engendered in all farming systems. In the public sector, family members were employees of local administration, forestry units, schools, and nature reserves. Income from employment/private business was high in MFD and LFD and lowest in HFD. A larger share of this activity was seasonal employment as construction labour in the residential villages (34%-48%) and taxi drivers (15-37%), in which male family members were engaged. Small village shopkeeping was observed in all villages, with 2-4% of the family members engaged. Family engagement in tourism was high in MFD and LFD (10-25%) because of the natural attractions, while the percentage of HFD farmers engaged in tourism was negligible. MFD and LFD farmers tried to capitalize on the growing tourism by selling farm produce or providing services to tourists.

6.1.3.5 Livestock production and economic output

Livestock was, as noted, a significant source of income in silvopastoral households and most important cash savings account in all three types of farms. Cattle and horses dominated the total herd composition; sheep herds were small and averaged no more than 6 sheep per farm. Raising chickens supplemented the production of chicken meat and eggs, mainly for home consumption. According to farmers from all groups, the number of livestock in their farms increased by 1-3 LU over a recent decade, MFD farmers increased their herd sizes the most. The increase in livestock was marked by the fact that farmers invested more remittance money in livestock production, i.e., for the purchase of additional livestock.

Figure 10 illustrates herd size and composition of silvopastoral farming systems. HFD farmers had a moderate herd size (5.48 LU) and it consisted of local steppe cattle (67% of total animals), horses suitable for milk and meat production (27%), and sheep suitable for meat production (6%). Farmers raised livestock mainly for sale, with an average of 28% of their herd sold annually, with the remainder kept for herd reproduction. The share of slaughtered animals for household consumption was negligible in this cluster. The average MFD herds were largest among the clusters and amounted almost 13 LU per farm. These were composed of cattle (53%), followed by horses (35%) and sheep (12%). Because the herds were quite large, the share of sold livestock was greatest in this cluster (36%), and the slaughter of livestock for family consumption, although small (5% of the herd on average), was the greatest among all clusters. LFDs had the smallest herds, with the share of cattle highest among the clusters (73%), while horses accounted for only 20% of the total herd. The share of sheep/goats was 7%, which was similar to HFD. The share of livestock sold from LFDs was the least of the three clusters – 14% of the total herd, which is not surprising considering the small size of the herds.

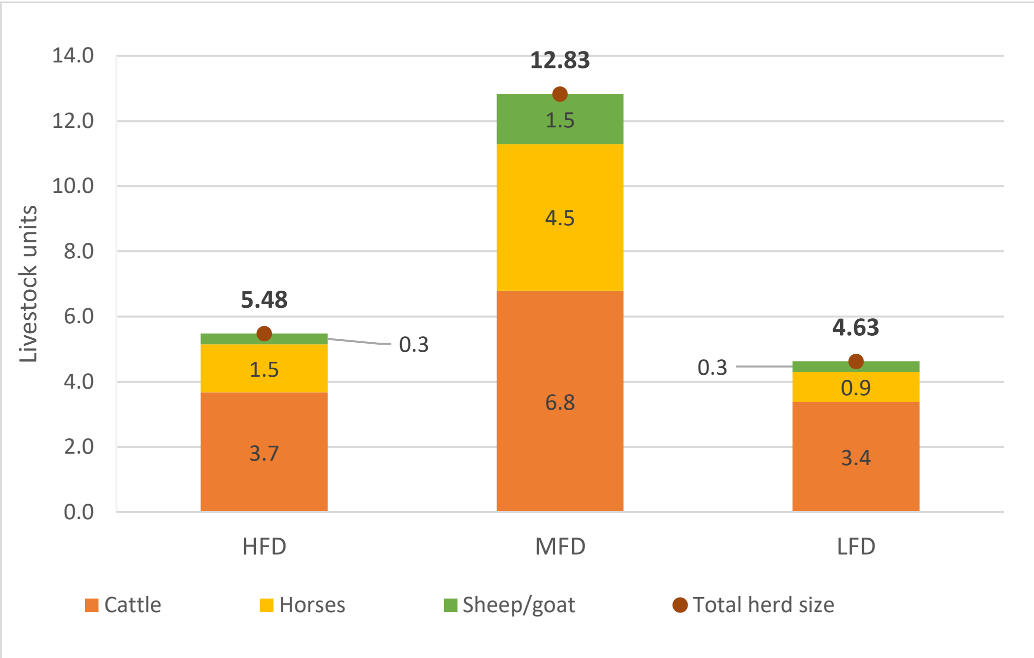


Figure 10 Average herd sizes of farm-households of high, middle and low forest dependent farms (HFD,MFD and LFD) in south-western Tien Shan mountains

The gross margin (GM) per livestock unit and economic outputs of animal production are based on the arithmetic average of the sample population (Table 10). The table shows the gross margin for each type of animal in terms of one livestock unit (LU), i.e., a cow makes one LU, and a horse is 0.8 while 5 sheep/goats equate to one LU. The structure of benefits and costs revealed that generally the major cost factors that influenced gross margins per livestock unit were winter fodder and the replacement of animals. Other variable costs included medicine, veterinarian services, and feeding of offspring, which were much less than winter fodder costs. The upkeep cost of sheep in HFD and LFD was unknown as farmers bought ewes or young rams and fattened them for a month in barns, then sold them and reportedly made a profit of 15-26 USD per fattened ewe/ram. The GM for raising animals varied and was positive, with values ranging between 76 USD/LU for sheep and 446 USD for horses. Mares had the highest GM per LU in all groups of farms and among animal types within groups due to high market prices and low feed costs as horses were grazed year-round. Cows were the second most profitable animal in all groups due to the high price of offspring, milk, and culling, while sheep had the lowest margin per LU in all farms. Overall, the comparison of the GM among clusters show that the highest GM per LU and animal types were in the LFD farm group due to higher milk productivity of dairy cows and the sale of animals at high market prices compared to the other clusters. The gross margins of dairy cows, mares, and sheep were about the same in HFD and MFD. It is noticeable that gross margins of mares were the highest in all clusters, as horses, including mares and foals, usually graze in pastures for up to 12 months, resulting in low feeding costs (half as much as dairy cows). The gross margins of the entire herd owned by MFD farmers were the highest (2733 USD), more than double those of other types of farming systems. Gross profit of the entire herd of LFD farmers (1373 USD) was higher than that of HFD farmers (1066 USD), although LFD had the smallest herds among clusters. Most farmers sold cattle in autumn when the animals returned fat from remote pastures, but it is noteworthy that 40% of LFD farmers sold cattle in winter and spring when livestock prices were generally high. Overall, results show that LFD farmers were more productive in livestock production compared to the other farming systems.

Table 10 Gross margins in livestock production

	HFD			**MFD**			**LFD**		
	Dairy cow	Mare	Ewe✦	Dairy cow	Mare	Ewe	Dairy cow	Mare	Ewe✦
Gross output:									
Milk yield, USD	77	-		118	-	-	154	-	
Wool/hair, USD	-	-		-		-	-	-	
Offspring[1], USD	353	418		351	454		434	511	178
Culling[2], USD	111	118		121	110		0	120	101
Total gross output, USD/LU	541	536		590	564		588	631	279
Variable costs:									
Herd replacement[3], USD	96	124		110	120		-	110	93
Milk for offspring, USD	45	-		65	-	-	35	-	
Fodder (Hay/cereals), USD	132	66		111	106		139	63	69
Service of herder, USD	0			0			0		
Medicine, vet service, USD	24	12		20	25		16	12	11
Total variable costs, USD	298	202		306	251		190	185	173
Gross margin, USD/LU	242	334	89	284	313	76	398	446	106
(Std. dev.)	(56)	(119)	(24)	(553)	(423)	(16)	(379)	(212)	(59)
*LU**	1.8	1.8	0.3	4.5	4.3	1.1	1.9	1.2	0.3
Subtotal gross margins, USD/LU	435	605	26	1286	1365	82	769	570	34
Total gross margin for whole herd, USD/herd		**1066**			**2733**			**1373**	

[1] price of offspring up to two years of age; loss of calves and foals deducted from offspring; [2] cows and mares are used for 7 years; loss of cows and mares deducted from culling; [3] heifer, ewe etc.; * Livestock unit, one LU corresponds to one cattle, 0.8 horses, or 5 sheep/goats; **HFD** - high forest product dependent farms; **MFD** – middle forest product dependent farms; **LFD** - low forest product dependent farms.

6.1.3.6 Feed availability and animal feeding calendar

The total forage resources available for livestock production were obtained mainly from designated forest pastures located 12-15 km from villages, as well as designated pastures near the settlements (usually for milking cows), limited and less frequently arable land, and kitchen gardens of crop residues (grazing on arable land and meadows after harvesting). When pasture vegetation senesced, animals were fed roughage, i.e., hay and small amounts of concentrated fodder (barley, maize grain). Natural pastures, meadows, and purchased legume hay were the dominant fodder resources in all villages, as livestock grazed in forests all year round and prepared fodder was fed supplementarily, mainly in winter. Products such as grass silage were not used at all. According to most farmers, the quality of purchased legume hay was perceived by farmers as good, and considerably better than hay harvested from meadows which quality was rated by farmers as mediocre.

The total quantity of available winter feedstuff produced and purchased by farmers is shown in Table 11. More than 95% of MFD and 98% of HFD farmers purchased mainly meadow and legume hay, maize stalks, and barley grains in addition to what was produced in their meadows. LFD farmers harvested on average twice as much meadow hay compared to HFD and MFD; nonetheless, the share of purchased hay was predominant in LFD (84%). About 30% of all is farming systems purchased additional fodder in late winter or early spring, reflecting the shortage of fodder during this period. On average, the total amount of winter fodder available for whole herd was 6495 kg DM in HFD, 10580 kg DM in MFD, and 6004 kg DM in LFD farms. The winter ration of cattle was undiversified and sparse, as it consisted entirely of roughage in the form of hay and stalks. The proportion of concentrated feed in the form of barley was just over 2%.

Table 11 Total winter feedstuffs for herds in preparation for winter

	HFD	MFD	LFD
Herd size, LU*	5.48	12.83	4.63
Meadow hay (own), kg DM	87	498	952
Meadow hay (purchased), kg DM	3857	1306	75
Legume hay, kg DM	2011	7860	4224
Maize stalks, kg DM	224	250	544
Barley (grain), kg DM	316	612	208
Total feedstuff, kg DM	6495	10580	6004
(Std. dev.)	*(4671)*	*(10414)*	*(3941)*

HFD - high forest product dependent farms; **MFD** – middle forest product dependent farms; **LFD** - low forest product dependent farms; DM- -dry matter; * Livestock unit, one LU corresponds to one cattle, 0.8 horses, or 5 sheep/goats; DM- -dry matter.

The energy demand of an animal was determined by the maintenance requirement, which is linked to live (body) weight and age of animals (cf. herd composition in Table 10, Figure 10), the energy needed for live weight gain and output (e.g., milk production in dairy cows). Furthermore, the requirements for gravidity and motion were also considered. However, practically, the number of feedstuffs required for herd maintenance and production depends on the feed energy content, its digestibility, and content of digestible protein and other essential nutrients (Appendix 4). On average, the daily amount of DM needed per LU or dairy cattle (300 kg live weight) ranged from 8.1 to 10.9 kg in winter (Table 12). The different amounts of feed in the three farming systems can be explained by the fact that the proportion of low-quality feed (meadow hay) was higher in HFD and MFD, while the proportion of higher quality feed (legume hay) was significantly higher in LFD (cf. Table 11). On average, HFD farms with an average herd size of 5.48 LU required a total monthly amount of 1559 kg DM. MFD farms, with a larger average herd size of 12.83 LU, required 3772 kg DM per month, while in LFD farms, with a smaller herd size of 4.63 LU, the total monthly amount of DM required was 1155 kg. These monthly feed quantities were applied to the summer months and remained constant over the entire year because during warmer months animals walked longer distances and needed more energy for motion, while during cold months animals expended less energy in motion but needed more energy to maintain optimal body temperature. Table 12 shows that the approximate equal distribution of available feed for the different animals was not sufficient during winter in the HFD and highly insufficient in the MFD, while the LFD had an adequate amount of winter fodder. The inadequate nature of winter and early spring grazing, combined with insufficient feeding owing to fodder economy, fails to sustain the body weight of livestock. As a result, there was a high mortality rate and a heightened level of risk associated with livestock rearing system. It is worth noting, however, that despite these challenges, farmers have not decreased the number of animals they keep; in fact, they often tried to maintain or even to increase their livestock holdings. This underscores the traditional cultural significance of livestock, which extends beyond its function as a mere means of economic sustenance, serving instead as symbols of wealth and social status.

Table 12 Required and actual feed intake for different types of livestock and the whole herd in winter based on energy value calculations of available feedstuff

	Necessary daily and monthly feed intake				Actual daily and monthly feed intake			
	Dairy cow/LU (300 kg), kg DM/day	Sheep (60 kg), kg DM/day	Horse (360 kg), kg DM/day	Total herd, kg DM/month	Dairy cow/LU (300 kg), kg DM/day	Sheep (60 kg), kg DM/day	Horse (360 kg), kg DM/day	Total herd, kg DM/month
Feed amount for adult animals and total herd of 5.48 LU* in **HFD**	10.9	2.3	13.1	1559	8.5	1.7	10.2	1112
Feed amount for adult animals and total herd of 12.83 LU in **MFD**	9.3	2.0	11.2	3772	6.1	1.2	7.3	2351
Feed amount for adult animals and total herd of 4.63 LU in **LFD**	8.1	1.9	8.3	1155	8.1	1.6	9.7	1133

HFD - high forest product dependent farms; **MFD** – middle forest product dependent farms; **LFD** - low forest product dependent farms; *Livestock unit, one LU corresponds to one cattle, 0.8 horses, or 5 sheep/goats; DM- - dry matter.

The 'feeding calendar' (Figure 11) illustrates the annual feeding opportunities and gaps in the silvopastoral farming systems. Animals (except dairy cows) usually returned fat from the remote pastures to the villages by late September/early October depending on weather conditions and joined the dairy cows, which grazed year-round in the pastures near the villages. Until the onset of winter, all the animals were left grazing in the forest pastures and meadows near the villages where they remained fat due to available fodder throughout the month of October. From November onwards, following the arrival of snow cover, winter fodder stocks usually prevailed as the major fodder source. However, depending on weather conditions, these were supplemented by grazing in pastures and meadows near settlements.

From December onwards, animals of HFD and MFD farms typically suffered significantly from the lack of fodder and started to lose body weight due to insufficient feeding. The lack of winter fodder prevailed until April, as farmers tried to save their feed as long as possible from late autumn until late spring. Animals of LFD farms, in contrast, did not suffer from lack of forage and did not lose body weight throughout winter due to sufficient winter feed stocks. In all farming systems, at the onset of spring animals were left to graze on shrubs and grass in forests before the new cropping season, regardless of the fodder availability. However, according to most HFD and MFD farmers, during this grazing period the fodder intake of animals was negligible, and they remained emaciated. From March to late April, with the beginning of the vegetation growth period, farmers fed the remaining winter feed stocks to their animals and increasingly kept them in the same pastures near villages so that these once again became the main feed source. However, animals typically did not gain weight during these weeks as there was not yet enough feed on these pastures. From mid-May to June, animals, except dairy cows, that had been pastured near the villages all year, migrated to the remote pastures again. During this time, animals had enough feed on the pastures and started to gain weight, and in July, all animals were fat and in good condition.

The results of the analysis of the annual feeding cycle show that the forage base depended on forest pastures (including meadows) near the settlements as well as on remote pastures. Forest pastures near villages were intensively used in spring and autumn due to the lack of winter fodder, which caused considerable land degradation (Appendix 10). Winter fodder from HFD and MFD farms was not sufficient to meet animal needs for about 5.5 months from November to May and during this period the animals suffered from lack of fodder and most farmers were not able to sell their livestock as the animals were emaciated. As a rule, the price of livestock increases during the winter until the early summer. In contrast, the LFD animals of farmers had sufficient feed and remained in good condition all year round.

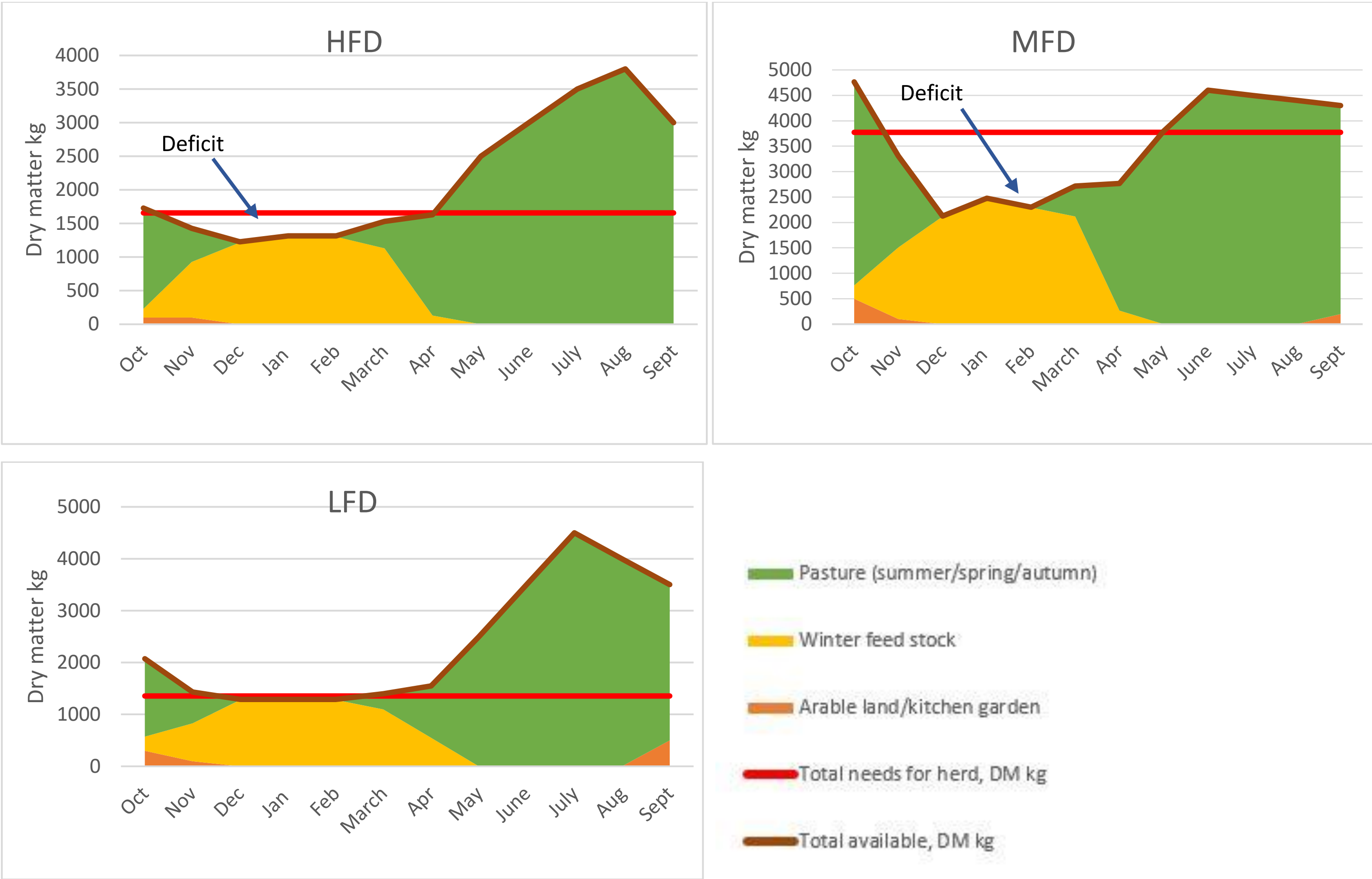


Figure 11 Estimated monthly feed availability in dry matter (DM) according to main feed sources and total needs of the herd of high, middle and low forest dependent farms (HFD,MFD and LFD) in south-western Tien Shan mountains

6.2 Classification of farm popuations in central Tien Shan mountain ranges (relevant to Objective 1)

6.2.1 Socio-economic characteristics of agropastoral farm-households

This section is answering research question 1 about the prevalent farming systems in central Tien Shan mountains, research question 2 about methods suited to classify these farming systems.

Animal husbandry

According to discussions with local community workers and the survey data, livestock production was the most important economic activity and basic source of income. Fat-tailed sheep and local steppe cattle, and horse breeds suited to meat production also dominated in this area. Average herd size was 16.3 livestock units. A typical herd consisted of an almost equal number of sheep (34.5%), horses (32.5%), and cattle (30.5%). The productivity of animals for milk and meat outputs was 1080 kilograms of milk for each cow's lactation cycle and ≈150 kilograms carcass weight per cow, respectively. Local experts assessed these values as mediocre given that the farm production system was characterized as low input and low output. Furthermore, experts stated that animal productivity has slightly increased in recent years due to improved feed supply. All livestock, except dairy cows, were kept in high mountain pastures during the summer months. Most farmers used the services of professional herders whose grazing practices can be attributed to the transhumance system. As a rule, each village has several dozen family herders who, after collecting all livestock from villagers, move to remote mountain summer pastures ('*Jailoo*' in Kyrgyz language) and stay there during the entire summer (3-5 months). However, the word '*Jailoo*' can also be applied to the process of animal grazing during summer. The meaning of the word is quite wide and may imply both place and the process of grazing itself. Villagers pay about ten USD per LU and month. About 12% of the farmers interviewed were professional herders. Animals were kept in pastures, if possible, to reduce the amount of fodder required during winter. The grazing period can last up to 11 months depending on environmental conditions.

Cropping systems

As already described in the literature review, the land redistribution in the 1990s resulted in larger average farm size at higher elevations given the lesser land quality and lack of irrigation opportunities, which impeded agricultural production in these areas. The largest portion of cultivated land was used to grow grass, fodder legumes for hay making, and fodder cereals, mostly barley (*Hordeum vulgare* L.) and very rarely oats (*Avena sativa* L.). Potatoes (*Solanum tuberosum* L.), wheat (*Triticum aestivum* L.), and vegetables were grown on smaller plots of land, mostly in kitchen gardens for domestic consumption and income generation. Local community workers remarked that farmers achieve mediocre crop yields. Experts attributed this continuing mediocre rise to the increased legume production and improved crop rotation. Farmers commonly used services of contractors for ploughing and harvesting, as only few farmers (4%) owned such machinery. Most of this agricultural equipment, such as Soviet tractors and combines, is old, privatized back in the 1990s during the distribution of the property of collective and state farms.

Income sources from non-agricultural activities

While the opportunities for off-farm employment and the business opportunities are generally low, some farmers obtain a large part of their income from off-farm sources. Pensions and salaries from public institutions make up more than half of the total off-farm incomes on average. There was also seasonal internal migration (mostly in the summer) to nearby larger towns and cities. Family members went to the capital, for example, and were employed as construction workers and in other services. It is notable that remittances from Russia, Kazakhstan, and other countries contributed a relatively small amount (12%) to the total income, but their importance in recent years has increased.

Agricultural markets

Markets were available in district capitals including the two largest livestock markets in Central Asia where mainly livestock and crop products were sold by farmers. The average distance to the markets was from 40 to 115 km, easily accessible by transport due to good road infrastructure. But the sale and purchase of livestock was done only on weekends (Saturday or Sunday) depending on the village and region. In some areas there was an increase in the number of private slaughterhouses where farmers could sell cattle. Every village had stores where food and other household goods could be purchased.

Farmers' perceptions of rangeland degradation and its causes

In this research region there were more than 40 community pasture management committees consisting of both pastoralists and local administration officials, including agronomists and veterinary technicians. According to local pasture committee workers, highland pastures and pastures near settlements cover nearly 90% of the agricultural land in this study area and fodder supply depends on these resources. They also reported that meadows and pastures near the villages were used intensively during spring and autumn due to insufficient winter feed, which induced significant pasture degradation due to trampling and subsequent soil compaction, especially when the soil was wet. Livestock numbers were increasing and therefore the pressure on pastures was increasing. Almost all pastures in the region are used, even the most remote ones, although there were some remote and barely accessible summer pastures where the committees planned to improve the road infrastructure at the time of the survey to stimulate the use of these pastures by herders. More than half of the interviewed farmers admit that the number of livestock has increased in recent years and that this trend has a negative impact on pastures. On the other hand, most farmers note that when cattle return from remote summer pastures in autumn, they were well-fed and gained weight, which showed that the livestock had enough fodder in the pastures.

6.2.2 Development of farm typology for agropastoral farm-households

Descriptive statistics for classification variables

The procedure for selecting classification variables was the same as described in section *6.1.2* and was aimed to find farm classes that are homogenous in their resource availability and use, production systems, socio-economic performance, and needs, as well as development constraints related to pasture and other resource degradation and management. Land holdings and livestock ownership data were highly variable with large standard deviations. Further exploration of these data using box plots indicates positive skewness due to outliers in the 90th percentile from land holdings greater than 30 ha and from livestock ownership larger than 40 LU. These outliers were discarded to improve the multivariate analysis and its generalization to the overall population. Out of the 235 households interviewed, two households had extremely large herds and cultivated areas, hence these were excluded from further data analysis. Although in some cases such outliers may represent better practices, however, a closer look revealed that these farm households had one of the following: (1) predominantly large yak herds and hired labour to graze yaks; (2) much farm machinery and provided services with this machinery; or (3) extensive arable land and grassland. Hence, the decision was taken to remove them from further analysis. Descriptive statistics for the remaining 233 farms are given in Table 13.

Table 13 Quantitative variables used in the principal component analysis (n=233)

	Variable	Minimum	Maximum	Mean	Std. Dev.
1	Herd size, LU*	1.10	42.20	16.30	8.94
2	Horses	0.00	31.00	5.34	4.83
3	Farm sales, USD†	0.00	26008	3797.00	4154.00
4	Sheep	0.00	36.00	5.43	4.04
5	Cattle	0.00	16.60	4.98	2.93
6	Fattened up animals	0.00	14.45	1.05	1.89
7	Cultivated area, ha	0.00	30.00	5.32	5.08
8	Fodder (Grain), metric tons	0.00	30.00	2.34	4.22
9	Fodder (Hay), kg	0.00	8695.70	690.6	751.20
10	Fallow, ha	0.00	27.00	1.41	4.15
11	Usage of fertilizer, kg/ha	0.00	500.00	20451.00	73.25
12	Altitude of village, m above sea level	1600	2300.00	1910.00	211.00
13	Irrigated area, ha	0.00	16.50	2.45	2.66
14	Barley yield, metric tons/ha	0.00	6.00	1.26	1.35
15	Pasturing period, month	4.00	11.00	7.83	1.38
16	Length of pasturing (hired herder), month	3.50	7.70	5.87	0.88
17	Remittances, USD†	0.00	6276.10	260.78	810.81
18	Off-farm income, USD†	0.00	14811.00	2249.00	2060.00

†In USD: average exchange rate in December 2013, 1.00 USD = 47.8 Kyrgyz som (adapted from www.oanda.com).
*Livestock unit, one LU corresponds to one cattle, 0.8 horses, or 5 sheep/goats.

Identification of key classification variables

The PCA assessment had a modest but 'passable/acceptable' KMO value of 0.668 (Kaiser & Rice, 1974) and Bartlett's test of sphericity showed a significance level of 0.00 which indicated that the variables were related and therefore could be analyzed using PCA. Out of the 18 PCs generated, five PCs with eigenvalues > 1, accounting for 64.4% of the variability, were selected (Tables 14, 15 and 16).

Table 14 Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett test of sphericity

Statistical Tests		
Kaiser-Meyer-Olkin Test		**0.644**
Bartlett's Test of Sphericity	Approx. Chi-Square	1951.000
	df	143.000
	Sig.	0.000

Kaiser-Meyer-Olkin value must be greater than 0.6;
Bartlett's Test (df: Degree of freedom, Sig: Statistical significance, $p<0.00$)

The first PC explains 20.0% of the variability in the data set, while the second and third PCs explain 14.4% and 11.3%, respectively. PCA components four and five explain 10.7 and 7.9% of the variance, respectively. PCs were characterized according to the loading factors within each PC.

Table 15 Principal components with eigenvalues above Kaiser's criterion of >1

Total Variance Explained						
	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.576	25.421	25.421	3.604	20.022	20.022
2	2.678	14.879	40.299	2.601	14.450	34.472
3	1.839	10.215	50.515	2.035	11.308	45.780
4	1.371	7.619	58.134	1.926	10.698	56.478
5	1.137	6.316	64.450	1.435	7.972	64.450
6	0.947	5.260	69.710			
7	0.757	4.203	73.913			
8	0.745	4.138	78.051			
9	0.689	3.829	81.880			
10	0.623	3.463	85.343			
11	0.565	3.136	88.479			
12	0.554	3.077	91.556			
13	0.486	2.702	94.258			
14	0.343	1.904	96.162			
15	0.283	1.573	97.735			
16	0.221	1.230	98.965			
17	0.139	0.774	99.739			
18	0.047	0.261	100.000			

[1]Extraction Method: Principal Component Analysis

PC 1 includes variables connected to livestock production, i.e., herd size, number of horses, cattle, and sheep. The second PC involves variables of crop production (cultivated area, fodder, and fallow). The third PC includes a combination of variables, like geographic elevation that influences the yield of crops, size of irrigated area, and use of fertilizer. The fourth PC covers livestock production; however, it relates to methods of animal raising, including the pasturing period. The fifth PC shows non-agricultural income sources, including total off-farm income and remittances (Table 16).

Table 16 Rotated component matrix of classification variables with factor loadings grouped in five principal components (PCs)

	Principal Component[1]				
Variable	1	2	3	4	5
Herd size	0.932				
Horses	0.795				
Farm income	0.699				
Sheep	0.672				
Cattle	0.659				
Fattened up animals	0.545				
Cultivated area		0.883			
Fodder (Grain)		0.824			
Fodder (Hay)		0.623			
Fallow		0.548			
Usage of fertilizer			0.693		
Elevation of village			-0.647		
Irrigated area			0.624		
Barley yield		0.521	0.584		
Pasturing period				0.904	
Length of pasturing (hired herder)				0.901	
Remittances					0.843
Off-farm income					0.806

[1]five components extracted using orthogonal Varimax rotation method with Kaiser Normalization. Associated variables with factor loadings >0.5 are allocated to the respective principal component.

Cluster profiles of agropastoral farming systems

In contrast to the clustering method applied to silvopastoral farms described in the previous sections, the hierarchical clustering based on Ward's method was applied to agropastoral households. Before conducting a cluster analysis, the selected classification variables derived from the PCA were tested for relationships among the variables to avoid double weighting. For “cultivated area” and ‘herd size’, a positive relationship (r = 0.7) was obtained. We selected the variable with greatest standard deviation, as proposed by Hardiman et al. (1990). Therefore, the variable ‘cultivated area’ was selected. Table 17 shows four remaining variables that were not correlated with each other and subjected to the cluster analysis.

As noted, the hierarchical clustering based on Ward’s method was used for grouping similar farms. The resultant dendrogram indicates (Figure 17) that two main clusters of farming systems can be delineated based on four variables derived from PCA and correlation analyses. Elevation was the most important factor in characterizing major farming systems. The dotted line shows the selected cut-off point, which gave a two-cluster solution (Types 1–2). The vertical axis represents the agglomeration coefficient (the ‘height’ or distance between clusters merged at each stage).

Table 17 Non-collinear variables used in hierarchical agglomerative cluster analysis

Variables		Elevation of village	Cultivated area	Pasturing period	Off-farm income
Elevation of village	Pearson Correlation	1.00	0.096	0.011	-0.047
	Sig. (2-tailed)[1]		0.144	0.867	0.477
	N	*233*	*233*	*233*	*233*
Cultivated area	Pearson Correlation	0.096	1.00	-0.017	-0.024
	Sig. (2-tailed)	0.144		0.799	0.721
	N	*233*	*233*	*233*	*233*
Pasturing period	Pearson Correlation	0.011	-0.017	1.00	0.051
	Sig. (2-tailed)	0.867	0.799		0.435
	N	*233*	*233*	*233*	*233*
Off-farm income	Pearson Correlation	-0.047	-0.024	0.051	1.00
	Sig. (2-tailed)	0.477	0.721	0.435	
	N	*233*	*233*	*233*	*233*

[1]The Sig. (2-Tailed) values are >0.05 indicating no statistically significant correlations among variables.

Two distinct mixed crop-livestock farming systems were identified, which significantly differed in terms of their agroecological and socio-economic conditions. These clusters were classified as:

Cluster I: ***Upper jailoo***[6] farms (UJF) located in high-elevation mountain ranges between 2000 and 2400 m a.s.l, mainly based on fodder and livestock production and characterized by a reduced pasturing period and a low off-farm income (Figure 12).

Cluster II: ***Lower jailoo*** farms (LJF) located in medium-elevation mountain ranges between 1500–2000 m a.s.l., mainly based on fodder and livestock production and characterized by a reduced pasturing period and a low off-farm income.

Figure 13 shows the locations and distribution of farms of the upper jailoo farms located between 1500 and 2000 m a.s.l. in Kochkor and Kemin districts (red dots) and farms of the lower jailoo farms located between 1500 and 2000 m a.s.l. in Kochkor and Kemin districts (green dots).

[6] 'Jailoo' means primarily highland summer pastures in Kyrgyz language. However, it could also imply the process of grazing itself.

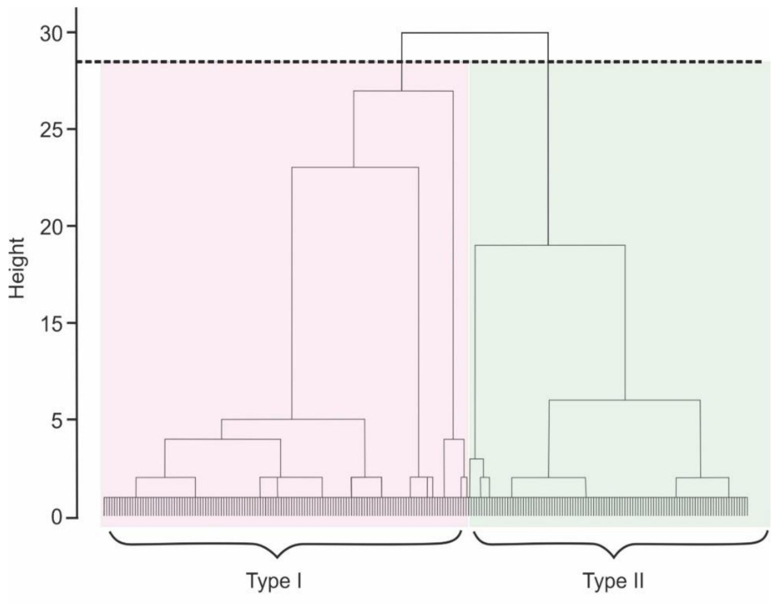


Figure 12 Dendrogram showing the range of cluster solutions resulting from Ward's method.The dotted line shows the cut-off point, indicating a two-cluster solution. 'Height' displays the agglomeration coefficient or distance between clusters merged at each stage.

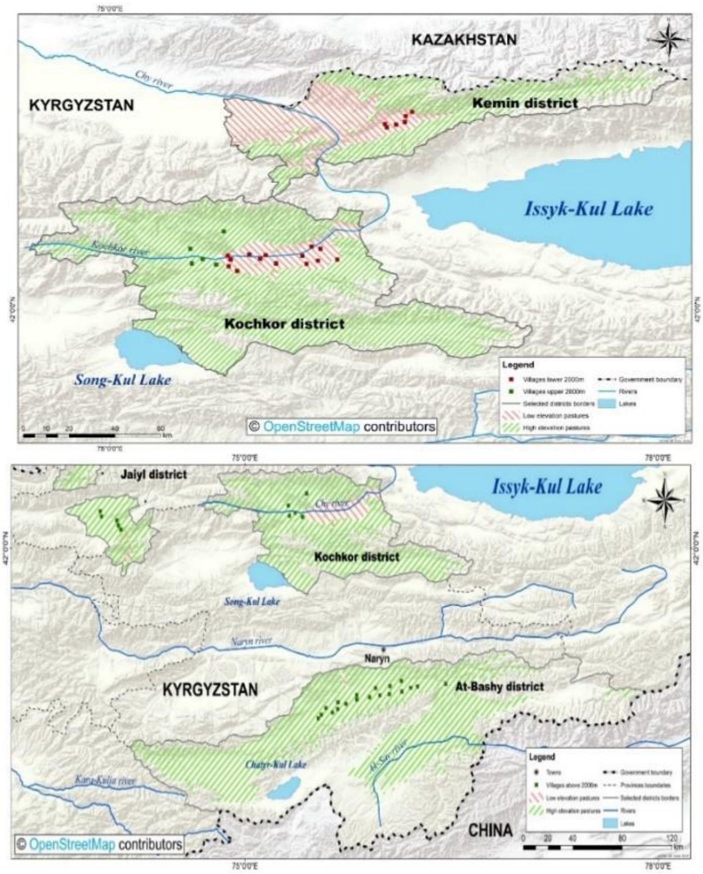


Figure 13 Distribution of the classified farming systems across central Tien Shan mountains (green dots – villages >2000 m a.s.l.;red dots – villages <2000 m a.s.l.)

These systems show distinctive differences in their classification parameters (Table 18). All variables were subjected to one-sample t-tests to identify significant differences among variables and subsequently farm types. All the selected classification variables showed significant differences among classes (Appendix 5).

Table 18 Characteristics of the agropastoral farming systems in central Tien Shan mountains according to their classification parameters

Variable	Unit	*Cluster/Types of farms* Upper jailoo farms (n=125)	Lower jailoo farms (n=108)
Elevation of village location*	m above sea level.	2200.0	1700.0
Pasturing period*	month	7.2	8.5
Cultivated area*	ha	5.9	4.7
Off-farm income*	USD†	1933.0	2616.0

†In USD: average exchange rate in December 2013, 1.00 USD = 47.8 Kyrgyz som (adapted from www.oanda.com).

6.2.3 Resource management and socio-economic performance of agropastoral farming systems

This section is answering research questions 3 about the characteristics of the farming systems and how can they be differentiated based on resource allocation, socio-economic performance, agricultural production methods and off-farm income sources.

6.2.3.1 Human resources

Family labour resources are analyzed similar to procedures used in section 6.1.5.1. The age of family heads varied within and between farming systems and averaged between 57 (LJF) and 61 (UJF). The proportion of interviews with female family heads was 8% in LJF and 13% in UJF. Average family size was smallest in LJF and consisted of 5.07 family members, while in UJF it was slightly more than 5.5 (Table 19). Most families in each farming system were extended families living in the same household (most often parents and their children, including spouses and grandchildren). This explains the high number of adult family members.

The most intensive labour force available in both farming systems was engaged in agricultural production. While livestock production required the labour of one member of the family for about 2-3 hours daily and regardless of the season, crop production required the labour of all family members during the growing season (e.g., weeding, watering) and most intensively during the springtime sowing (vegetables) and the harvest season. Weeding was done only a few times during the summer. Collection of hay and herding were the responsibility mostly of male family members, while milking cows and processing of milk was the work of female family members. As a rule, hay was cut with machinery, but the press cylinders were collected manually and brought by truck to the farm (less frequently by horse-drawn cart) and unloaded by hand. The duration of work in home gardens was short, not more than an hour a day in summer, and was mainly done by female members or children (11-17 years old). In general, the whole family was engaged in the harvesting of crops. Among the crops grown by farmers in both clusters, fodder legumes and meadow grass harvesting required the least labour inputs, as most of the work was done by contractors' machinery (mowers, balers). In contrast the cultivation of potatoes in both clusters, and sugar beets and haricot beans in LJF required more labour and usually all family members were engaged in their cultivation. However, such cash crops were rarely grown by LJF farmers.

Table 19 Family size and labour capacities in farm-households in central Tien Shan mountains

	Clusters/Types of farms	
	Upper jailoo farms (n = 125)	**Lower jailoo farms** (n = 105)
Family size, persons	5.50	5.07
(Std. dev.)	*(1.71)*	*(1.74)*
Male child (0-10)	0.76	0.72
Male child (11-17)|0,5|LF	0.87	0.42
Men >18/|1,0|LF	1.12	1.58
Female child (0-10	0.65	0.65
Female child (11-17)/|0,5|LF	0.33	0.18
Women >18 |1,0|LF	1.74	1.50
Total available labour force (LF)	3.47	3.39
Family members with off-farm income	2.10	2.56
(Std. dev)	*(1.58)*	*(1.49)*
Number of migrants	0.24	0.29
(Std. dev.)	*(1.88)*	*(1.85)*

LF – labour force

LJF farms had more family members (2.56) with sources of income from off-farm activities compared to the UJF (2.1). Although off-farm employment was an important activity where inputs of human resources were required, in both farming systems the share of income from pensions prevailed, indicating the high age of family heads and low employment rate in the villages. If there was extra time away from agricultural production, adult male family members were engaged in seasonal work as casual laborer during summertime (1-2 months).

6.2.3.2 Land resources

As alluded to in the literature review, based on land redistribution as well as other assets owned by collective and state farms 20 years ago, the analysis of land resources shows a difference in land allocation between the two farming systems. This is reflected in the size and quality of land and irrigation capacities, i.e., UJF farmers on average had almost twice as much land as LJF farmers, as population density in remote areas (higher elevations) was generally low and therefore they received more land per capita. But at the same time during the Soviet period there were no irrigation systems on these lands; thus, UJF farmers had the least irrigated land. The situation for LJF farmers was opposite because the population density was higher in the lower elevations farm-households which received less land per capita, but with a good irrigation infrastructure built during the Soviet period. There was a high demand for irrigated arable lands in both farming systems and farmers rarely sell or rent land to farmers outside their own family. The quantity and the timing of irrigation was a major factor for crop productivity.

Table 20 shows the main features of land resources of farming systems in the central Tien Shan study site. On average, the UJF farmers hold 8.4 hectares of arable land. The share of non-irrigated land was 75% contributing to the low productivity of agricultural land at higher elevations. About 2.5 hectares of fallow land was recorded per farm-household, mostly attributable to low fertility or remote locations and limited access to agricultural machinery. The quantity and the timing of irrigation water was a major factor for crop productivity in each village. Farmers in a few villages complained about the need to renovate irrigation channels and the unreliable water supply from the mountains. Farmers in this cluster hold an average of 4.9 hectares of arable land and 0.2 hectares of fallow land, significantly lower in comparison to UJF farmers. On average, 80% of cultivated land was irrigated and rainfed land was mostly in meadows.

As in the case of silvopastoral systems it was not possible to calculate the exact pasture area per farm, but according to the local administration officials there is about 5-10 ha of pasture per farm, but this figure varies quite a lot from village to village. In almost all villages there were tendency of overgrazing on certain pastures and under grazing on other pastures (this refers to all pastures, both remote summer pastures and pastures near the settlements).

Clear measures to determine the carrying capacity of the allocated pastures were present in half of the surveyed villages. Local experts acknowledge that the most overgrazed pastures were near the settlements.

Table 20 Land resources of upper jailoo and lower jailoo farms in central Tien Shan mountains

	Upper jailoo farms	Lower jailoo farms
Total farmland, ha	8.4	4.9
(Std. dev)	*(9.07)*	*(2.84)*
Shares of fallow and cultivated land:		
Uncultivated area, %	30	4
Cultivated area, %	70	96
Cultivated area, ha	5.9	4.7
(Std. dev)	*(5.37)*	*(2.82)*
Shares of irrigated and non-irrigated land:		
Irrigated land, %	22	81
Non-irrigated land, %	78	19

6.2.3.3 Crop production and economic output

The results show that the village elevations and climate cause different agro-climatic conditions for crop production in farming systems. The variety of cultivated crops by UJF farmers was low due to climatic conditions (Figure 14). Cultivation of livestock fodder comprises the largest share of the cultivated cropland; almost 97% of the actual cultivated (irrigated and rainfed) land was used to grow meadow grass (47%), sainfoin (*Onobrychis viciifolia* Scop.) for hay making (27%), and fodder cereals (mostly barley) (23%). Potatoes, wheat, and vegetables were grown on the remaining 3% of the land. Vegetables were grown mostly in kitchen gardens for domestic consumption. Most of the non-irrigated land was utilized for hay production. In the irrigated plots, legume crops were typically grown, mostly sainfoin and small amounts of alfalfa (*Medicago sativa* L.). Sainfoin was one of the main crops in almost half of the farms; its cropping area has grown due to a proportionate reduction in areas of wheat, barley, and other crops in recent years. This increase was driven by the high profitability of sainfoin cultivation due to low labour demands (including minimum soil tillage) and the availability of contractor services (e.g., combine harvesters for wheat/barley were less available than mowers). Additionally, the marketing of legume hay was easier compared to other crops, including vegetables. Cereal yields were generally low and hence there was limited cultivation of wheat and oats. Wheat was not used for feeding, but for home consumption, while wheat straw was fed to animals. Barley was the most important crop and mainly used in concentrated livestock feed. In addition, the cultivation of barley was also important because it was an important component in crop rotations.

LJF farmers produced somewhat more variety of crops, while the largest part of the cultivated land was also used for fodder crops to make hay (56%) and fodder cereals, such as barley (22%). Wheat (10%), potatoes (8%), and cash crops, such as sugar beets (*Beta vulgaris var. altissima* Döll) and haricot beans (*Phaseolus vulgaris* L.), were also important (Figure 19). Crop yields were higher in comparison to UJF because of more favorable climatic conditions and better irrigation infrastructure accompanied by increased use of chemical fertilizers and pesticides. LJF farms achieved higher yields of legume crops; cultivation of alfalfa was more productive (average hay yield of 6.4 metric tons/hectares) compared to sainfoin in UJF (average yield of 3.3 tons/hectares). This was mainly because farmers in LJF had two (very rarely three) harvests per year, benefiting from better irrigation facilities and more favorable climate. Home gardening (horticulture) also contributed to market sales in LJF.

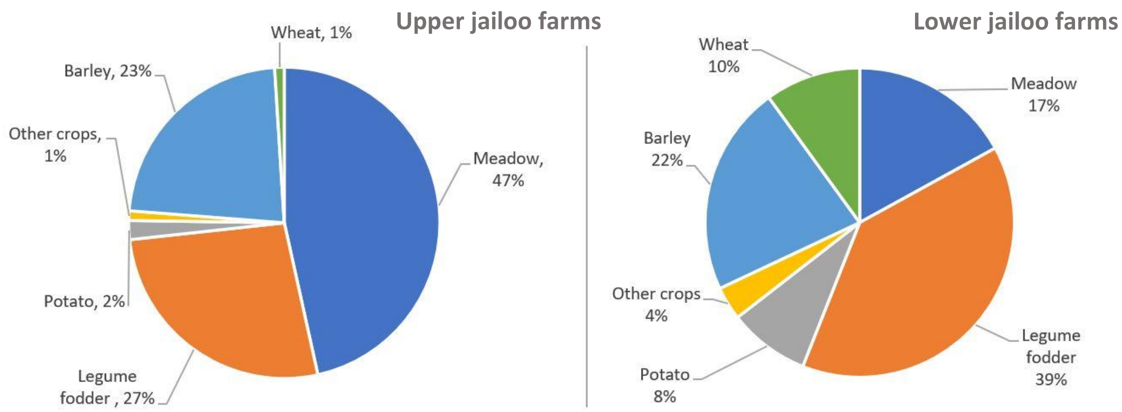


Figure 14 Proportion of cultivated crops in upper jailoo and lower jailoo farms in central Tien Shan mountains

The main costs in crop harvesting were contractor services in both types of farming systems. Although it is worth noting that the level of mechanization and, in general, the availability of farm machinery was higher in LJF compared to farms in UJF. There was also a difference in expenditures for contractors' services, e.g., UJF farmers paid about 10-12% more to contractors than LJF farmers. Machinery ownership and availability within the groups was slightly higher in LJF i.e., 7% of LJF farmers had machinery, while 6% of LJF farmers had machinery. In general, this machinery was old equipment belonging to former collective and state farms. All farmers with farmland ownership provided services to other farmers. It is worth noting that there was a shortage of combines for barley harvesting in UJF farms. Seed costs were relatively low (compared to costs for contractor’s services), as most farmers did not buy certified varieties of seeds. Family labour was not included in the expenditure because of the general low employment rates in all villages.

Calculation of gross margins per ha of cultivated crops showed that the most profitable crop was potato (3160 USD for UJF and 2470 USD for LJF), but the size of arable land with potatoes was larger in LJF 0.38 ha than in UJF 0.12 ha (Figure 15). LJF's potatoes were mainly grown for sale, while UJF's share of potato sales did not exceed 30% of the total potato yield. This crop required the highest input of both labour and financial resources in both farming systems. The other most profitable crop was legume fodder crops, i.e., alfalfa in LJF and sainfoin in UJF), which was provided 870 USD/ha and 300 USD/ha, respectively. The income of LJF farmers was more than twice that of LJF farmers due to harvesting legumes twice per year on LJF farms. Legume fodder crops are perennial and required reseeding every three to four years. In addition, these crops were the least labor-intensive as the harvesting was done by machinery. The least profitable crops were cereals such as wheat, barley, and oats, as well as meadow grass (rain-fed fields), the economic output of which ranged from 120-230 USD/ha. Overall, LJF farmers were the most productive in all types of crops per ha compared to UJF farmers. This was due to what has already been described as the result of more favorable climatic conditions, better irrigation systems, and productive inputs, such as fertilizers. Morevover, LJF farms

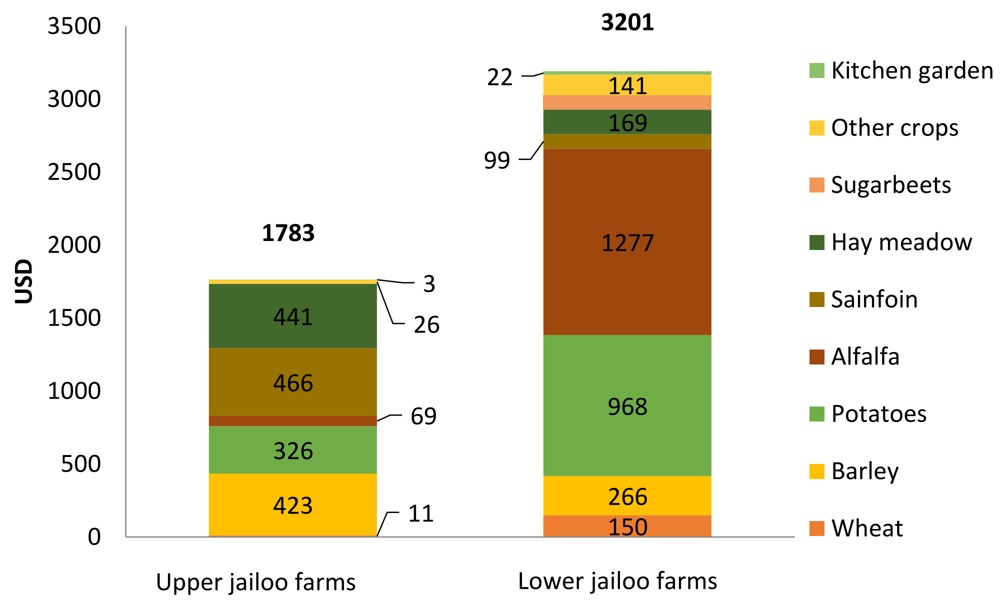


Figure 15 Total net incomes from crop production in upper jailoo and lower jaloo farms in central Tien Shan mountains

LJF farms had the highest annual net income from crop production at 3201 USD, while UJF farmers had almost half as much (1783 USD per year). Potatoes and legume fodder crops (alfalfa and sainfoin) contributed most to total crop production income in LJF, followed by barley, wheat and meadow hay, since these crops occupied the largest area arable farmlands. The contribution of other crops to the total income was smaller but in total accounted for 7% of the overall income from crop production and the standard deviations of these incomes were quite high. UJF farms had the highest income from sainfoin (less alfalfa), meadow hay, and barley followed by other crops which in total generated 4% of total crop income. The proportion of sold re-growth products in LJF was significantly higher and accounted for 37.2% of production, while in UJF it accounted for only 17.3% of production. Poor irrigation facilities were the main problem of UJF farmers, which limited the productivity of more profitable crops.

6.2.3.4 Non-agricultural activities and off-farm income

A substantial part of family income was generated by off-farm activities in both farming systems. There was a significantly higher annual off-farm income of 2616 USD in LJF compared to UJF (1933 USD) reflecting better non-agricultural employment opportunities in LJF. Pensions and salaries from public institutions made up 1411 USD or more than 70% of the total off-farm incomes while remittances and private business made up the remaining 27%, reflecting poor access to non-agricultural employment and business opportunities (Figure 16). Similar to UJF, pensions from government and salaries from public sector were also major income sources for LJF farmers. Notably, remittances did not dominate in both farming systems, in UJF these were only 11% and in LJF 16% of all off-farm income. Remittances were mainly from Russia and less frequently from other far-abroad countries. According to farmers in both groups, migration, both internal and external, has increased in recent years. The share of income from employment/private business was about the same in both farming systems - 16% in UJF and 17% in LJF of all off-farm income. A large portion of this was seasonal work as construction workers in residential villages and taxi drivers (freight inclusive) in which male family members were employed. The maintenance of small village shops was observed in all villages and the involvement of families in tourism was low in both clusters. The tourism business mainly consisted of renting yurts and horses to tourists, as well as selling fermented mare milk (‘kymyz’ in Kyrgyz language) and other processed dairy products and handicrafts, such as wool carpets.

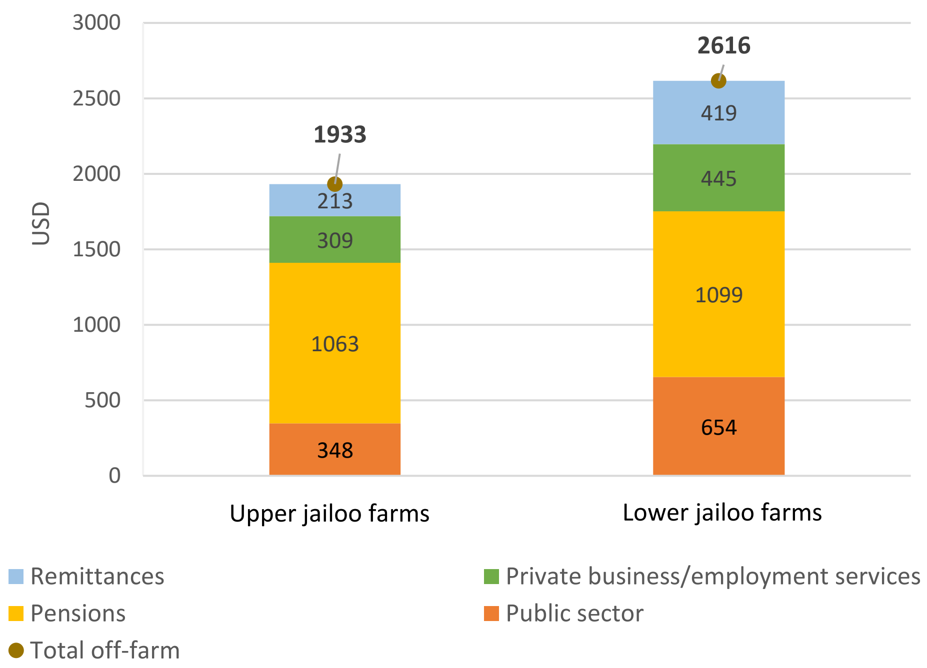


Figure 16 Income contributions from different off-farm activities of upper jailoo and lower jailoo farms in central Tien Shan mountains

6.2.3.5 Livestock production and ecomomic output

Livestock production was the most common economic activity and the basic source of income in UJF and LJF. Farmers in both clusters depended on highland summer pastures ('jailoo') because their animals grazed there. However, they could participate in the process directly or indirectly through taking the animals to pastures themselves or hiring professional. As a rule, each village has several dozen family herders who after collecting all the livestock from the villagers, move to remote mountain summer pastures and stay there during the entire summer period. Villagers paid to professional herder about five USD per livestock units per month. According to farmers from both groups, the number of livestock in their farms increased over 30-34% in the recent decade. The increase in livestock was marked by the fact that farmers had no other more advantageous sources of income.

Figure 17 illustrates herd size and composition of UJF and LJF farming systems. No significant differences in terms of herd sizes were observed; farmers had an average herd of 16.4 livestock units in UJF and 16.2 in LJF. A typical herds consisted of an almost equal number of sheep/goats (35% in UJF and 34% in LJF), horses (30% in UJF and 35% in LJF), and cattle (31% in UJF and 30% in LJF). Farmers also owned a small number of other animals, such as yak (3% in UJF and 1% in LJF) and poultry (0.05%). Raising poultry supplemented the production of chicken meat and eggs mainly for family consumption. Farmers raised animals both for sale and for family consumption, on average 35.7% and 33.2% of the herd was destined for sale in UJF and LJF farms, respectively. Horses were mainly sold when the family needed large amounts of cash, and sheep when less cash was needed. Most farmers sold livestock in autumn when the animals returned fat from highland pastures, but it is noteworthy that almost all farmers kept a few animals, most often sheep and young cattle, fat during winter to sell them if the farmers needed cash. Livestock prices in winter and spring were usually high. The share of animals slaughtered for family consumption (mainly sheep, goats and cattle) was quite significant in both farming systems (particularly in comparison to silvopastoral farming system) and amounted to an average of 17% in UJF and 15% of the total herd in LJF farms and remainder kept for herd reproduction. Approximately half of the herd in both farming systems was kept for herd reproduction.

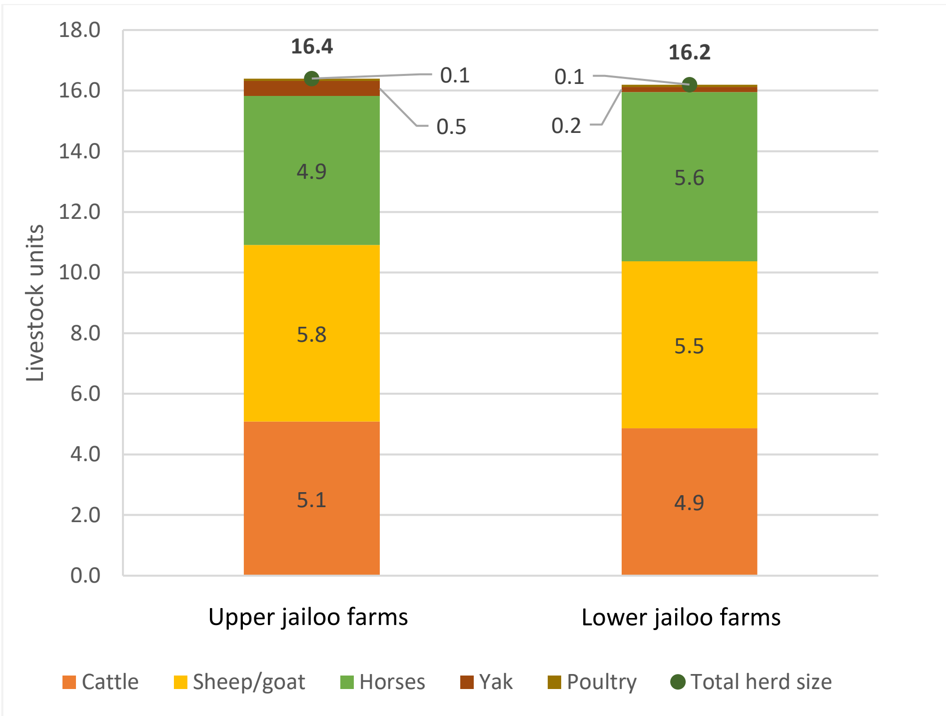


Figure 17 Average herd sizes of upper jailoo and lower jailoo farms in central Tien Shan mountains

Gross margin and economic outputs of animal production were calculated as described in section 6.1.5.5; in addition, the detailed gross margin calculations of each animal are given in the (Appendix 6). Figure 23 shows the total gross margins from livestock production, i.e., total herds of both farming systems. In general, the LJF farmers compared to UJF farmers were more productive in terms of livestock production (in particular per horse and cattle). LJF farmers had in general low feed costs, on the one hand the produced and purchased feed costs was lower, on the other hand UJF farmers grazed animals longer than UJF farmers, which enabled them to keep animals in good condition longer period in winter. In addition, LJF farmers were selling animals at higher prices as they generally had easy access to large markets not only for marketing but also for agricultural inputs. Income from horses compared to other animal types was highest in both groups of farms, as horses grazed for long periods (up to 12 months especially in LJF), resulting in low feed costs (half as much as for dairy cows). LJF farmers sold horses at a higher price and the share of horses in the total herd was higher than in UJF, which explains greater total GM from horses. While the GM of cattle was almost the same in both farm groups (with a slight difference in both GM per head and total herd), the total GM of sheep/goats was higher in UJF, because sheep numbers and selling prices of these animals were higher in UJF farm group. Overall, the analysis of total herd GM was highest in the LJF (2352 USD) and slightly less in UJF (2145 USD) even though UJF's herds were slightly larger. In LJF farms, profits from horses (1195 USD) followed by cattle (534 USD) contributed the highest margins to the total gross margin, while in UJF farms, cattle (828 USD) followed by horses (684 USD) contributed the highest margins to the total gross margin. Gross margins for sheep and goats combined were about the same (more than 530 USD) in farming systems. The gross margin contribution from yaks was small because the number of farmers with yaks was negligible in both farming systems (Figure 18). As a rule, yaks were located year-round in the highlands in the open pastures and did not need to be controlled all the time. Farmers with yaks in both farming systems had a few yaks within a large herd shared with their relatives. These large herds of yaks were under the complete control of UJF and LJF farmer relatives; yaks were checked once a month and, if necessary, driven to the highland pastures closer to the villages if they wandered away into the mountains. Yaks are semi-wild and were not milked and were only destined for meat production. Yaks did not need supplementary feeding and were self-sufficient in pastures. The main expense of yak raising was the loss of animals through the killing of wolves, which was quite high and amounted 25% loss of yak herds.

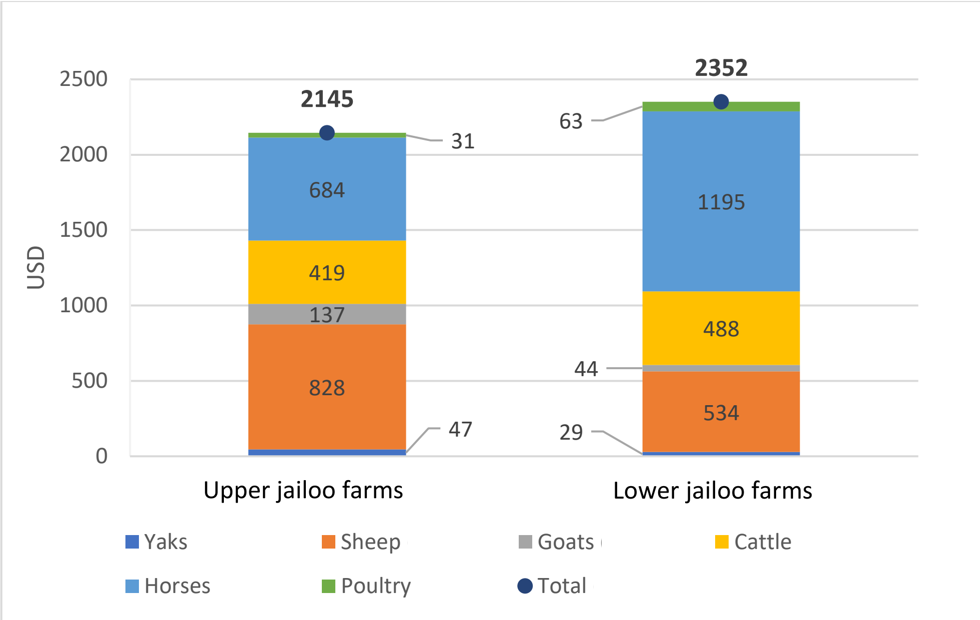


Figure 18 Total gross margins of the entire herds in upper jailoo and lower jailoo farms in central Tien Shan mountains

6.2.3.6 Feed availability and animal feeding calendar

The energy demand of animals was calculated similar to silvopastoral farming systems and described in section 6.1.5.5. The total quantity of feedstuffs produced and purchased by farmers is shown in Table 21. The total forage resources available for livestock production came from pastures, arable land, meadows near the cropping areas, and crop residues (grazing on cropland and meadows after harvest). Generally, natural pastures, meadows, legumes, and meadow hay were the dominant feed resources in the study area. The share of concentrated feed in the form of barley and oats was small; products such as grass silage were not used at all. According to most farmers, the quality of grass on the pastures as well as the feed that was produced was mediocre. However, the quality of legume (sainfoin) hay was indicated as good, significantly better than the hay collected from grass meadows. About 10-12% of farmers sold a part of their fodder, and about 50% farmers of both groups purchased different types of fodder in addition to what they produced on their farms. These amounts were subtracted and added, respectively, to compute the total livestock feed balance.

Table 21 Total winter feedstuff for herds in preparation for the winter

	Upper jailoo farms	Lower jailoo farms
Herd size, LU:	16.4	16.2
Barley/wheat straw, kg DM*	2426	1968
Alfalfa/Sainfoin hay, kg DM	4960	8914
Meadow hay, kg DM	3403	1730
Barley (grain), kg DM	3391	2051
Oat (grain), kg DM	296	249
Alfalfa/Sainfoin hay purchased, kg DM	2146	1125
Alfalfa/Sainfoin hay sold, kg DM	807	749
Barley (grain) purchased, kg DM	224	266
Barley (grain) sold, kg DM	408	1378
Total available, kg DM	15630	14175
(St. dev.)	*(22195)*	*(15451)*

*DM - dry matter; *Livestock unit, one LU corresponds to one cattle, 0.8 horses, or 5 sheep/goats; DM- -dry matter.

According to farmers, hay, and other crops, including cereals, were sold to contractors immediately after harvesting due to cash limitations. By contrast, 50% of farmers purchased additional fodder, both hay and cereals. Most of these farmers purchased additional fodder in winter or in early spring, reflecting the fodder scarcity during this period. On average, the total amount of available winter livestock feed was 15,630 kg DM per UJF farm and 14,175 kg DM per UJF farm; the standard deviations of these figures within the groups were high (cf. Table 21). The energy demand of an animal was calculated similarly as described in section 6.1.5.5. The predominant part of the winter ration consists only of roughage in the form of hay and straw, whereby the proportion of legume hay was more than 50% in both farm clusters. However, the proportion of concentrated feed (barley and oats) was more in UJF farming systems. On average, the daily amount of DM needed per LU or dairy cattle (300 kg live weight) was 7.5 kg DM in UJF farms and 8.8 kg DM in LJF in winter (Table 22). The different amounts of feed in two farming systems can be explained by the fact that the proportion of concentrated feed (barley and oat grains) was higher in UJF (cf. Table 21). On average, the total monthly amount of DM needed per farm herd with an average of 16.4 LU in UJF was 3751 kg DM and in LJF, 4200 kg DM for in LJF. These monthly feed quantities were applied to the summer months and remained constant. Table 22 shows that the approximate equal distribution of available feed for the different animals and herd composition (cf. herd composition on Figure 17) was not sufficient during winter in both farming systems. Despite the feed shortages and deterioration of animal health, farmers in these agropastoral systems do not reduce livestock numbers. This can be attributed to the saving mechanism, which not only represents subsistence but also financial security, as well as traditional cultural reasons. These reasons are similar to those described in the silvopastoral farming systems, as discussed in sub-section 6.1.3.6.

Table 22 Required and actual feed intake for different types of livestock and the whole herd in winter based on energy value calculations of available feedstuff

	Necessary daily and monthly feed intake				Actual daily and monthly feed intake			
	Dairy cow/LU *(300 kg), kg DM/day	Sheep (60 kg), kg DM/day	Horse (360 kg), kg DM/day	Total herd, kg DM/month	Dairy cow/LU *(300 kg), kg DM/day	Sheep (60 kg), kg DM/day	Horse (360 kg), kg DM/day	Total herd, kg DM/month
Feed amount for adult animals and total herd of 16.4 LU* in **UJF**	7.5	1.6	9.3	3751	6.5	1.3	7.8	3200
Feed amount for adult animals and total herd of 16.2 LU in **LJF**	8.8	1.8	10.5	4200	8.1	1.6	9.7	3850

UJF – upper jailoo farms and **LJF** – lower jailoo farms; *Livestock unit, one LU corresponds to one cattle, 0.8 horses, or 5 sheep/goats; DM- -dry matter.

The 'feeding calendar' (Figure 19) illustrates the annual feeding opportunities and gaps in the two agropastoral farming systems. Most farmers in both clusters (90%) used the services of seasonal professional herders. Herders remain in high pastures an average of 4.3 months. The average grazing period in UJF was 7.2 months due to environmental constraints during the cold season. In LJF, the average grazing period differed significantly and lasted on average 8.5 months, reflecting the longer growing season. Farmers of both groups generally attempted to keep their animals in pastures or on arable lands as long as possible to minimize the amount of feed stocks required for animals kept on farms during winter. Animals typically returned from the highland pastures to the villages in October after the crop harvest, when this was permitted by the local government. Until the onset of winter, animals were left grazing on the pastures and meadows near the villages where they remained fat due to the sufficient availability of feed throughout October. From November, after the arrival of snow cover, the winter feed stocks typically dominated as the major feed source. However, depending on the weather conditions these were supplemented by grazing pastures, meadows, and arable plots near the settlements. From December on, animals typically suffered significantly from the lack of fodder and started to lose body weight due to insufficient feed. This lack of winter fodder prevailed until April, as farmers tried to save their feed as long as possible from late autumn until late spring. During the onset of spring, animals were left grazing shrubs and grass on arable land and meadows before the beginning of the new cropping season. However, according to most farmers, during this grazing period the fodder intake of animals was negligible, and they remained emaciated. From March to late April with the beginning of the vegetation period, farmers fed the remaining winter feed stocks to their animals and kept them increasingly on meadows and pastures near villages so that these became the main feed source again; animals typically did not gain weight during these weeks as there was not enough feed on these pastures. From mid-May to June, animals, except dairy cows, which were kept on pastures near villages year-round, migrated to the higher pastures (*jailoo*) again. During this time the animals had enough feed on the pastures and started to gain weight again and in July all animals were fat and in good condition.

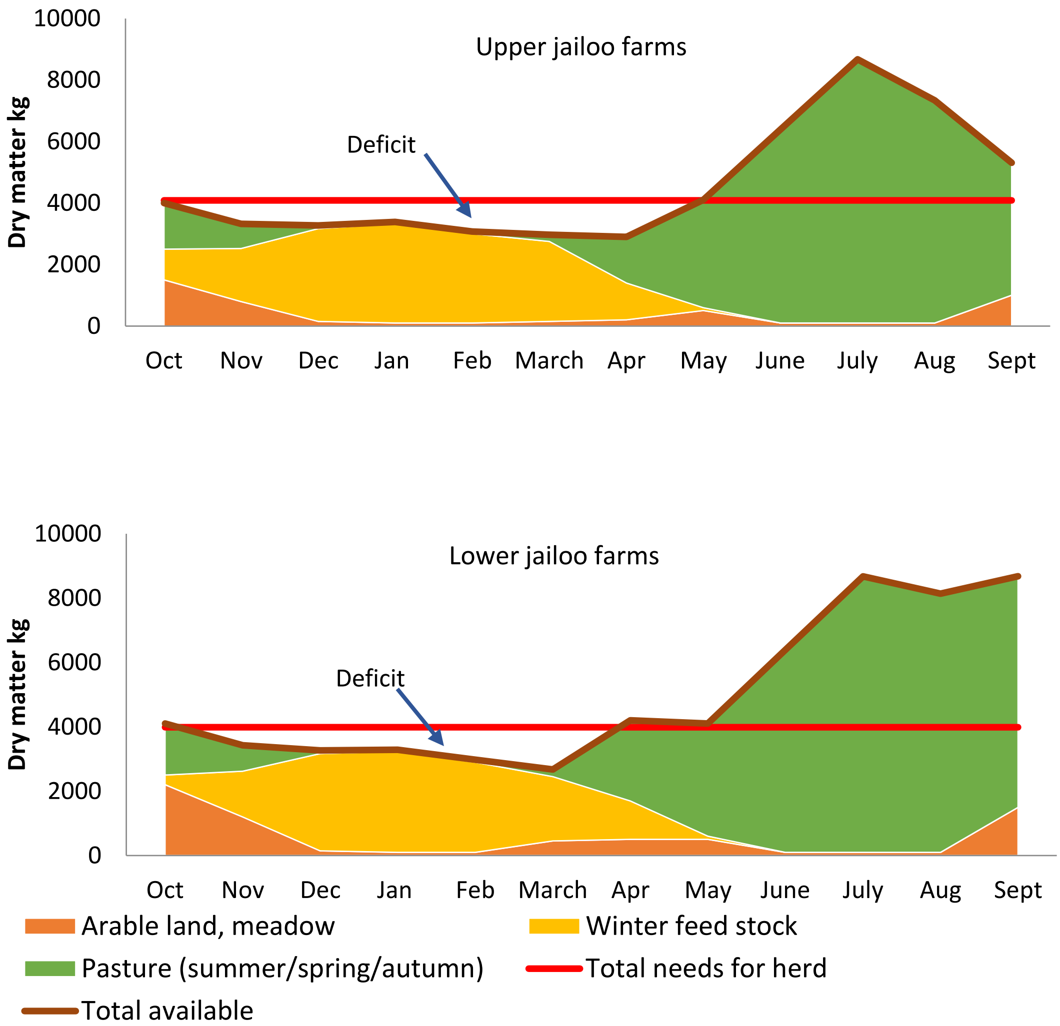


Figure 19 Estimated monthly feed availability in dry matter (DM) according to main feed sources and total needs of herds in upper jailoo and lower jailoo farms in central Tien Shan mountains

Summarizing the annual feeding cycle, fodder supply depended on the pasture (including arable land, meadows) near the settlements as well as highland pastures. The meadows and pastures near the villages were used intensively during spring and autumn due to the insufficient amount of winter feed available, which induced significant pasture degradation. It was also revealed that the supply of fodder was sufficient to cover the animal needs for approximately five months from June to October in UJF and for seven months from April to December in LJF. UJF herds suffered from a lack of fodder longer period than LJF herds.

6.3 Comparative socio-economic analysis of silvopastoral and agropastoral farm-households

This section integrates the analysis of family income, satisfaction of households needs and objectives of silvopastoral and agropastoral farming systems in the south-western and central Tien Shan mountains. The economic success in terms of farm income and family income is highlighted, followed by the analysis of economic security (research question 4). This includes annual cash availability and financial security. This section discusses usage of income and coverage of family member's needs. The family decision-makers and farmers' objectives, followed by the farmers' potential investments priorities analyzed in the final part of this section.

6.3.1 Family income and socio-economic success of farm-households

Family income is composed of income from farming activities and income from off-farm activities (Table 23). Farm income included both income from the sale of animals, from NTFP collection and additional farm income, such as from beekeeping, processing and sale of dairy products, and crop production (mostly meadow hay, followed by plums and surplus vegetables and fruits from home gardens). In agropastoral farming systems, some family income was derived through service provision using farm machinery (e.g., tractors) and herding services. The calculation of additional farm income was estimated by asking farmers how much net income they received from these types of farming activities per year. As can be seen, high deviations can be observed regarding these figures (Table 23). Some farmers within groups do not rely on any of these income sources while others were highly dependent and obtained a significant part of their farm income from beekeeping, herding and contracting services, and dairy product processing.

In silvopastoral farming systems, average rates of sales of crop products (e.g., plum apples, NTFPs) and animal products (e.g., milk and other dairy products exceeded 95%;

meadow hay was generally not sold and remained exclusively for feeding livestock on farms. The income generated by HFD farmers from other agricultural activities was the lowest among the clusters. In HFD, dairy products and apiary accounted for 183 USD and 47 USD, while crop production 41 USD. In LFD, the average annual income from dairy products was 756 USD, followed by crop production (456 USD) and beekeeping (182 USD); for all these indicators, farmers in this group had the highest income among the clusters. Dairy products accounted for most of the income as MFD had the largest herds dairy cows and hence more milk products for sale. Additional farm incomes of LFD farmers were moderate (higher than HFD but less than MFD) due to the fact that they were more productive, e.g., dairy products and grassland hay (see previous sections). The share of production and sale of dairy products also dominated as in other groups (319 USD), followed by income from crop production (130 USD) and beekeeping (92 USD).

Although the 'additional farm income' as a percentage of total family income in UJF (12%) and LJF (15%) were quite decent, the largest proportion of these incomes (> 90%) were from contractors and herding services. The standard deviations of these income sources were quite high due to the small proportion of farmers owning agricultural machinery (9% in UJF, 11% in LJF) and as well as professional herders (16% in UJF and 13% in LJF) providing services to other farmers in both clusters; however, seasonal incomes from these activities were quite high (Table 23). UJF farms obtained income from processed dairy 41 USD from providing services with private machinery 201 USD, while herding services delivered 243 USD per annum. The income from livestock in UJF was largest consisting of 34% of total farm income, while crop production income represented 28%. Market sales were low, and the share of livestock sales was two times higher in comparison to crop production (cf. 6.2.5.3 and 6.2.5.5). In general, in UJF, income derived from crop production varied more than income from livestock production. This illustrates that most farmers depended on livestock sales, while the number of agricultural products sold to markets varied considerably among farm households. The proportion of income from off-farm activities was slightly higher than income from crop production, 30% of UJF total family income. LJF farms. UJF farms obtained income from processed dairy 30 USD and from providing services with own machinery 201 USD, while herding services delivered 249 USD annually. LJF farms obtained higher revenues from livestock production than UJF farms due to easier market access and higher prices for animals. While sale of livestock was of comparable importance despite the low overall productivity of animal husbandry, crop production contributed more than 37% of family income in LJF, while income from animal husbandry contributed 27%. In LJF, the proportion of income from off-farm activities was slightly higher than income from livestock production and amounted to 30% of total family income.

Adding up all sources of income in silvopastoral farming systems shows that MFD farms had the highest annual family income (9272 USD), while HFD had intermediate income (6974 USD), and LFD the lowest (4578 USD). In terms of the average family income of farming systems, HFD farms have the highest share of NTFP income in total family income, showing the high importance of this activity in the livelihoods of these farms. Income from general farming (except NTFP income) as well as off-farming activities delivered about same amount of cash 1357 USD and 1429 USD, respectively, although in years when walnut harvesting was not possible, both activities came to the forefront. MFD farms had the highest income from off-farm activities (mostly remittances), followed by livestock farming due to the large size of the herd and income from NTFP collection. The small collections of NTFPs by MFD farmers were due, as described earlier, to a partial or total ban on NTFP collection. In general, MFD farmers are more secure in terms of family income through income from livestock production and more income from off-farm activities in case of no walnut harvesting. On the other hand, the lack of winter fodder limits livestock production and, as a consequence, income from this source. As in HFD, MFD farmers during the walnut crop failure focused more on increasing off-farm income by migrating seasonally within or outside the country. LFD farmers had the smallest income from NTFPs, because they did not have walnut forests, and the contribution of income from other NTFPs to family income was quite small. As such, income from off-farm activities and livestock were most important for farmers in LFD farms. It should be noted that with smaller herds, LFD farmers generated more income compared to HFD and animal productivity was the highest among the clusters. Moreover, the human resources in LFD farm were also used productively as they had the smallest number of family members; despite this LFD farm-households earned more off-farm income than family members in other clusters.

Table 23 Comparison of the annual family income among farming systems in south-western and central Tien Shan mountains

	South-western Tien Shan			Central Tien Shan	
	HFD	MFD	LFD	UJF	LJF
NTFP collection[1]/Crop production[2], USD[3]	4188	1908	550	1783	3201
(Std. Dev)	*945.0*	*218.6*	*183.9*	*330.5*	*784.8*
Animal husbandry, USD	1066	2733	1373	2145	2352
(Std. Dev)	*176.8*	*381.7*	*347.8*	*398.0*	*389.6*
Processing of milk, USD	183	756	319	41	30
(Std. Dev)	*41.0*	*285.5*	*159.6*	*12.5*	*8.1*
Meadow hay[2], fruits and vegetables from gardens, USD	41	462	130	10	33
(Std. Dev)	*24.0*	*163.3*	*48.0*	*20.7*	*3.6*
Beekeeping, USD	67	182	92	0	20
(Std. Dev)	*172.0*	*327.6*	*321.9*	*-*	*79.0*
Herding services, USD	n/a	n/a	n/a	243	249
(Std. Dev)				*651.2*	*761.9*
Service of contractors (farmers' machinery) , USD	n/a	n/a	n/a	208	226
(Std. Dev)				*361.9*	*413.6*
Farm income, USD	5545	6041	2464	4430	6111
(Std. Dev)	*(1670.9)*	*1488.1*	*990.2*	*1260.1*	*2288.8*
Off-farm income, USD	1429	3231	2114	1933	2616
(Std. Dev)	*1048.6*	*2544.5*	*920.2*	*1340.9*	*2400.3*
Family income, USD	6974	9272	4578	6353	8707

[1]applicable only for farm-households in south-western Tien Shan (**HFD** - high forest product dependent farms; **MFD** – middle forest product dependent farms; **LFD** - low forest product dependent farms); [2]applicable only for farm-households in central Tien Shan (**UJF** – upper jailoo farms and **LJF**- lower jailoo farms; [3]USD: average exchange rate in July 2021, 1.00 USD = 84.68 Kyrgyz som for HFD, MFD and LFD farms, average exchange rate in Dec 2014, 1.00 USD = 47.8 Kyrgyz som for UJF and LJF farms (adapted from www.oanda.com). NTFP – non-timber forest product

The comparison of total family incomes in agropastoral farming systems shows that LJF farmers had the highest annual family income (8726 USD), while UJF had the lowest (6363 USD). UJF farmers have the highest share of income from animal husbandry showing the importance of this activity in their livelihoods. This is also confirmed by the highest share of sales from livestock in UJF, while the crop production focused on producing fodder for the herd; small sales of crops covered the costs of contractor services during harvesting due to the shortage of cash. Income from off-farm activities was important and contributed the main constant cash flow to the UJF farmers. In contrast to UJF farmers, LJF had high shares of family income from both livestock and crop production; although crop production was also used to produce fodder for the herd, a good share of plant products was sold to generate cash. As in UJF, off-farm income by LJF farms was the main source of income providing a significant permanent cash flow.

6.3.2 Household expenditures and cash afflunce

In this section, based on the analysis of family incomes of farming systems described in sections 6.1.5.7 for silvopastoral farms and 6.2.5.7 for agropastoral farms, as well as the further data analysis, cash flow and cash outflows and their share, as well as basic annual household expenditures are analyzed. This analysis reveals the financial stability of households and the shortage or surplus of cash at certain times of the year. It also shows which sources of income are increasing or decreasing in households during the year.

The cash affluence or shortfall of the farming systems during the year and the main expenditures of the family show that the main family expenditure is on food (Figure 25). LFD spent more than 67% on food, HFD 64%, and MFD less compared to the other two but still more than half (54%) of all cash. In contrast to silvopastoral systems, agropastoral farms spent less on food - 40% of annual family expenditures in UJF and 36% in LJF. Other important expenditures were for celebrations and education, which together accounted for 24%-35% of the family budget in silvopastoral farms, and 37%-39% of budgets in agropastoral farming systems. In silvopastoral farms, utility costs (electricity, petrol, coal, mobile telephone) ranged from 7%-22% of the total family expenses. The share of total utility costs in agropastoral farms was higher (especially the costs for electricity and hard coal due to the long winters) compared to silvopastoral groups and amounted to 16% and 22% of annual family costs in UJF and LJF, respectively. Farmers from UJF (9%) and HFD (4%) had small but nonetheless definite cash surpluses, while farmers in LFD, MFD, and UJF had barely any surplus savings. It should be noted that expenses for agricultural productions, e.g., for fodder purchases or hiring labour during NTFP collection (mainly in HFD) and costs for hiring professional herders (UJF and LJF) were not considered here because they were already included in the gross margin calculations from each source of farming activities in previous sections.

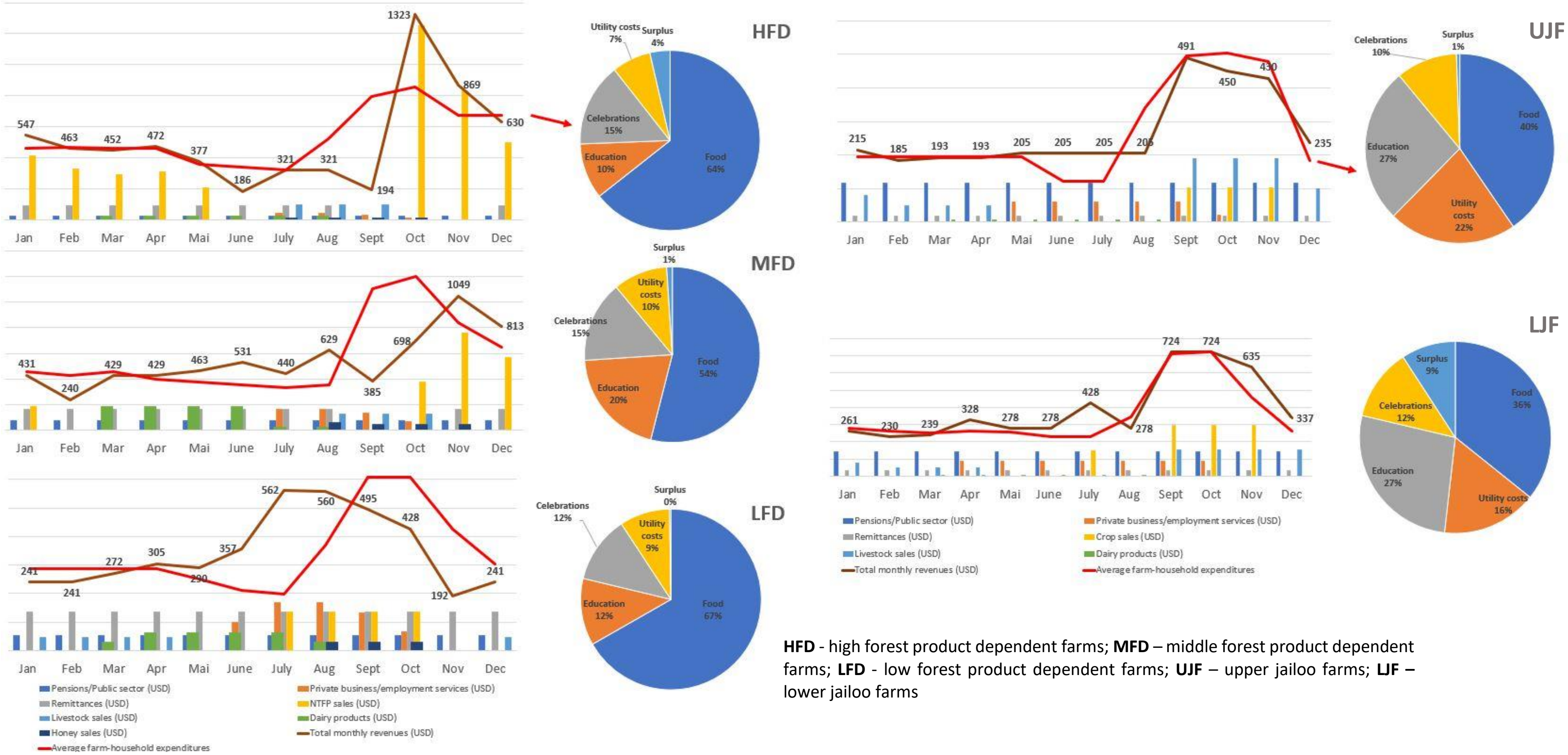
The stacked columns by month (Figure 20) show the diversity of income sources, which adds up to the total monthly income (brown trend line). The red trend line is the monthly expenses of the family; if it is below the brown line, it indicates that the farming system had a cash surplus ("savings") and if it was above this line there was a cash deficit. As can be seen from the graph, finances have been fairly stable with few fluctuations from January to August, mostly showing cash savings and less frequently showing deficits which were covered by savings from previous months. The low monthly cash flow (both income and expenditure) was in LFD and in both agropastoral UJF and LJF farming systems. The largest spikes in family expenditures were observed in the autumn in all farming systems due to the preparation of children for school, the start of the festive seasons [7]and purchasing coal for home heating.

In silvopastoral farming systems, largest cash deficits were observed in HFD and MFD from mid-August to October, in LFD from September to February. The highest cash inflows into family income were inextricably linked to receipts from NTFP sales in all farming systems, although there was a difference in seasonality among clusters. For example, HFD farmers and MFD farmers had the maximum income from NTFP sales (mainly walnuts) from October to December, whereas LFD farmers from July to October had wild raspberry sales in summer and walnuts in autumn, which were harvested by other hired farmers who received part of the harvest as labour payment. It is also interesting that walnuts served as a savings account for HFD and MFD farmers (like animals) as seen from sales from winter to spring (especially for HFD). This was also based on farmer strategies (both in HFD and MFD) to wait for higher prices for walnuts, which tend to be higher in winter. In agropastoral farming systems, the most severe cash gaps were observed in UJF from August to December (similar to LFD) and in LJF from February to May. The highest cash inflows to household income were inseparably linked to earnings from sales of crop products as well as sales of animals (including dairy products) in both farming systems, although there was little variation

[7] Weddings, including circumcisions and childbirths are accompanied by large celebrations and usually the invited relatives give a gift of 20 to 100 USD, depending on the closeness of the relatives. For such celebrations 100-200 people are invited, and on average families have to attend several dozen, often in autumn. However, this depends on the family and their strength of ties and the number of relatives and friends.

in seasonality of crop and animal sales. For example, LJF farmers started to receive income from crop production from mid-summer, whereas LJF farmers received income from October to November. In addition, LJF farmers sold animals from winter to spring more often than UJF farmers when animal prices were highest. This also explains why on average LJF farmers had higher gross margins in animal husbandry compared to UJF farmers who sold most of their herd in autumn when prices were generally low.

In general, income diversity increases from July to October for all farming systems due to increases in seasonal employment, other off-farm activities, and sales of other farm products. Overall, the monthly income from off-farm activities was insufficient to cover the monthly family expenditures in silvopastoral farming systems, while in agropastoral systems, off-farm income was sufficiently balanced and mostly sufficient to cover basic monthly cash needs. The low monthly expenditure was because production on UJF and LJF farms was more subsistence-oriented - e.g., no purchases of meat and vegetables were made as these were supplied from their own farms. Farmers of MFD and HFD covered the cash shortfall by selling stored walnuts and livestock, while LFD, UJF, and LJF mainly covered cash shortfalls by selling livestock or by using savings from previous months.



HFD - high forest product dependent farms; **MFD** – middle forest product dependent farms; **LFD** - low forest product dependent farms; **UJF** – upper jailoo farms; **LJF** – lower jailoo farms

Figure 20 Cash affluence in the farming systems of south-western and central Tien Shan mountains

6.3.3 Farmers' perspectives on living conditions and their future expectations for farming

Family members who were interviewed were mostly heads of families responsible for family decision-making; their perceptions regarding living conditions and objectives on the farm will be discussed in this section. This section will not examine family objectives related to their children, their education, or their future; it will examine family objectives for increasing income through farming activities, including plans farmers have in the near future related to agricultural production (collection of NTFPs only for silvopastoral farms). In the view of all family heads, their living situation has changed considerably in a positive direction during the past few decades. Fathers and mothers of households said this when referring to and comparing the times after the collapse of the USSR and the transition economy from the 1990s to 2010s. After 2010 all farms have seen a clear alleviation of hardship and poverty in their lives compared to the transition period. The main successes in improving life were that farmers reported an increase in their herds, a more systematic sale of farm produce including NTFPs (in newly emerged markets/traders for silvopastoral farms), and an increase in labour markets both domestically and abroad. Farmers interviewed did not classify their families as poor, but rather as middle-income families, rarely higher.

To increase farm incomes, all farming systems have pursued a prudent strategy in the recent decade, i.e., no radical change in production methods has been observed (except migration abroad/farm abandonment), most will continue to operate their farms as before with minor changes, and tiny investments in certain activities. Figures 21 shows the proportion of changes planned by farming systems in the near future.

The largest group of farmers in HFD and MFD (both 35%) and the second largest group of LFD farmers do not plan to introduce new innovations in agricultural production, as they are quite satisfied with the current state of farming. The most popular response from these farmers was that their youngest son (who usually inherits his father's house and farm) will decide on future changes on the farm. The other most frequent response among farmers in all clusters (29-30%) was plans to increase livestock numbers, some with a focus on increasing the number of horses and others intensive fattening of cattle for resale. Plans to process NTFPs and then sell them with added value were noted in 10% of HFD farmers, 17% in MFD, and 6% in LFD. Plans to produce honey were noted in LFD (14%), followed by HFD and MFD farmers (both 5%). Development of tourism business was most mentioned most by LFD farmers (11%); these plans were noted by 5% of farmers in HFD and MFD. Other plans (e.g., poultry farming, fisheries, migration) were not significant. Forest fencing was relevant for HFD farmers, as only they have leased forests, and this was planned to prevent grazing of other farmers' animals on their leased forest land and for improved collection of hay. Few plans were articulated for running private businesses and related off-farm activities, such as freight taxis, buying machinery (e.g., excavators), and providing services (e.g., service stations for cars). In contrast to silvopastoral farming systems, most farmers in UJF (66%) and LJF (55%) explicitly plan to increase livestock numbers, some with an emphasis on increasing the number of horses, sheep, and less frequently yaks, others opening sheds for intensive fattening of animals for subsequent resale (Figure 26). Farmers without any plans to improve farming activities were fewer compared to silvopastoral farming systems and accounted for 4% in LJF and more in UJF 14%. Plans to start private businesses were similar to silvopastoral farms and were aimed at increasing income from off-farm activities. The proportion of farmers with plans to start a private business (service station, taxi service, handicraft) was higher in LJF (14%), while in UJF, private business operations were planned by 6% of farmers. Plans to develop tourism were made by 7% of LJF farmers, the same proportion of farmers were planning to increase fruit trees in orchards and then process fruit. Only 2% of the LJF farmers had plans to produce honey. Plans to develop tourism were made by 8% of LJF farmers. Plans to open fisheries were only observed in UJF farms (2%). Farm abandonment (migration) was significant for LJF farmers (9%) and lower for UJF farmers (4%).

These results show that most farmers are planning small changes in their farms that require little investment, implying no radical changes in their usual agricultural production. Changes such as increasing livestock, orchards (in LJF), or trying honey production are not too risky, which demonstrates a commitment to conservative farming practices. On the other hand, in silvopastoral farming systems, increasing the number of livestock needs additional winter fodder and hence additional costs in animal production, but given the high costs of fodder and the lack of arable land for farmers to produce their own fodder, most farmers realize that this is difficult to achieve. Developing tourism requires large investments and, according to most farmers, plans to do this in the near future are unlikely.

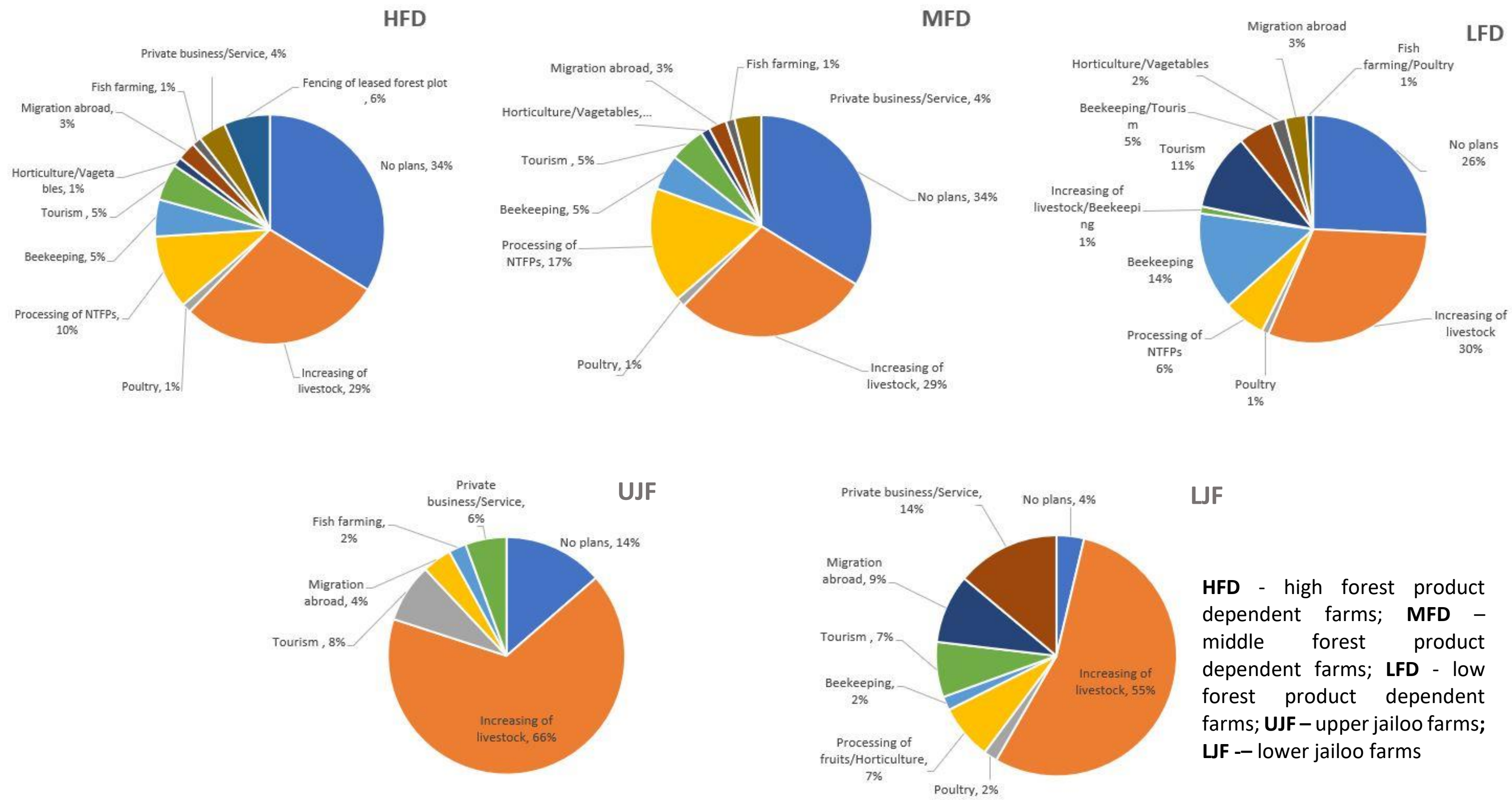


Figure 21 Objectives of farming systems with regard to improving farm operation in order to increase income from agricultural production

6.4 Summary of the methodological framework used to classify farming systems

In this section, a summary of the methodology applied in two study regions with the aim of identifying the different types of farming systems present in each area is described. Figure 22 presents an overview of the main steps involved in this process. To begin, it is recommended that a hypothesis is formulated, and research objectives are established based on general information, official data, previous research, and personal observations. This provides a basis for the development of a classification system. It is important to identify the key structural and functional criteria at the farm level, such as agricultural production methods, resources, assets, livelihood strategies, and household dynamics. Additionally, it is crucial to consider external factors that affect production systems and household livelihoods, such as altitude, climate, agroecology, land cover and use, infrastructure, and access to markets and technologies. By considering both the internal and external factors, hypotheses can be formulated about the nature of activities and land use in the agro-landscape, as well as recent changes, including resource degradation. Participatory approaches involving local stakeholders, such as forestry and rangeland workers, local experts, and farmers themselves, can be particularly effective in developing a farming system classification. Involving these individuals helps clarify the distinguishing criteria for different farm types and ensure that the questionnaire used in the farm survey phase is comprehensive and effective.

Developing a questionnaire to conduct a comprehensive survey that covers a large range of relevant aspects of the farming systems which we want to consider as determinants of the differentiation between systems. The survey questions should encompass a range of variables, including structural characteristics and farm functioning, resource availability and management, biophysical resources, socio-economic aspects, and economic and environmental indicators. The farm sampling process should cover the diversity of farms in the study area. The sampling method should be based on the initial hypothesis and expected proportions of farm types. Randomized sampling may require a large sample size, but methods such as stratification or utilizing gradients can reduce the sample size while still capturing diversity. It is not recommended to gather all farmers in one place to fill out surveys, as this may bias the sample. Farm visits can provide additional information.

Prior to selecting key variables for multivariate analysis, it is essential to assess the data quality in terms of its quantity and accuracy. Outliers, or potential errors or "exceptional" observations, should be identified and removed from the analysis through descriptive statistics due to their sensitivity to multivariate analyses. To ensure a systematic approach, variables related to the main components of the farming system, such as household/family, cropping system, and livestock system, along with their interactions with the environment, such as environmental, economic, and socio-cultural contexts, should be considered. The number of key variables utilized for classification purposes can vary, with an average of around 15-20 variables. The identification of key variables is followed by a Principal Component Analysis (PCA) to merge interrelated variables into principal components and extract final classification variables. To avoid over-representation of any specific variable category and prevent analysis distortion, a multicollinearity test is recommended. Agglomerative hierarchical or *K*-means cluster analysis is then performed using the key variables. Independent sample t-tests and ANOVA are used for comparing means of independent groups.

After identifying farming systems through clustering, conducting a comparative analysis of each system is crucial for gaining a deeper understanding of their strengths, weaknesses, and potential for improvement. This analysis should go beyond just examining crop and livestock production, and also consider economic outputs, resource allocation and utilization, as well as the farmers' objectives, constraints, and opportunities for agricultural production. Finally, by conducting a comparative analysis, it is possible to generate recommendations that consider the characteristics and technical aspects of the identified farming systems, with the aim of supporting the sustainability of both resources and livelihoods for the respective farm types.

Multivariate analysis also plays a critical role in establishing farm typologies, providing a basis for constructing mathematical models to simulate different scenarios on farms. Through this approach, it becomes possible to shed light on the development trajectories of the identified farm types. Specifically, in our study, the typology of agropastoral farming systems served as the basis for modeling of farm incomes. Main results and findings are presented in the following chapter.

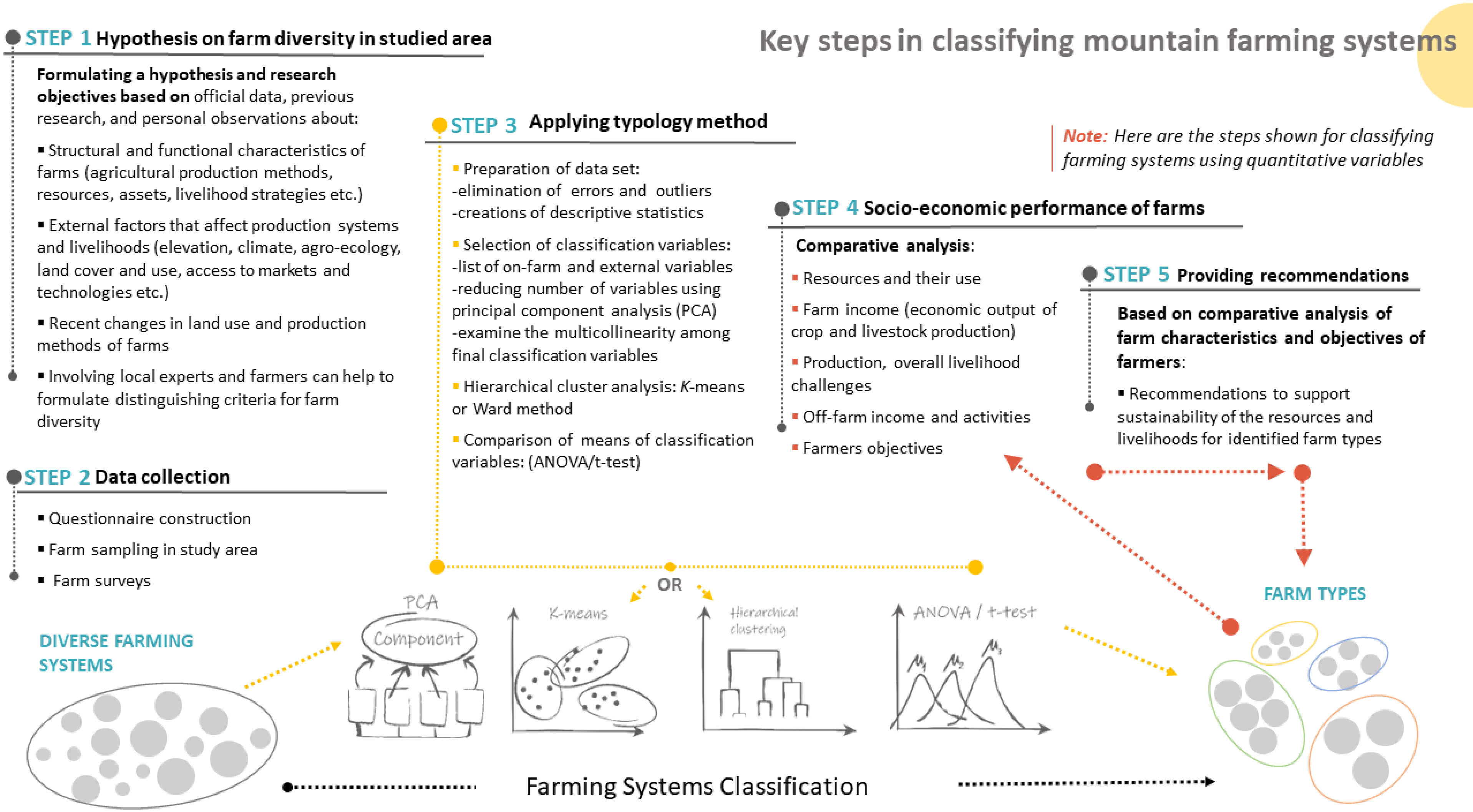


Figure 22 General framework of farm classification process

6.5 Simulation of farm income resulting from Kyrgyzstan's accession to the EAEU (relevant to Objective 2)

The results of objective 2 described in the following sections are based on a published research article by the author. Monte-Carlo modelling was performed to simulate the impact expected changes in the product prices and production or factor costs had on the net farm profit from animal and crop production for UJF and LJF farming systems resulting from Kyrgyzstan's accession to the EAEU. Net farm income was selected as the target output because it is the critical parameter to assess the impact of any changes in the production system on the farming families, and as it also embodies the combined effect of changes in uncertain independent variables. Table 24 shows the annual revenues and expenses in the main types of farmers' production systems. Income and expenses are based on the gross margin calculations described in the previous sections (cf. 6.2.5.3; 6.2.5.5; and 6.3.1.1).

Table 24 Basic mean socio-economic farm parameters for both farming systems

	Upper jailoo farms (n=109)	**Lower jailoo farms** (n=126)
Annual revenues from livestock production, USD	7130	8468
Annual revenues from crop production, USD	2782	4702
Additional farm income, USD	493	543
Annual subtotal revenues from farming, USD	10,405	13,713
Annual expenses of livestock production, USD	4976	6101
Annual expenses of crop production, USD	999	1501
Annual subtotal farm expenses	5975	7602
Farm income, USD	**4430**	**6111**

6.5.1 Expert-estimated price and factor cost changes and respective adaptation strategies of agropastoral farms

Changes in the uncertain independent variables expected from Kyrgyzstan's accession to the EAEU along with current and future adaptation strategies of farmers are shown in Table 25. All interviewed experts noted changes for most variables, although there were some notable differences in their assessment of the magnitude of changes for most variables.

Live animal prices were expected to increase gradually after the country's accession to the customs union to match the price levels in neighbouring EAEU countries, such as Kazakhstan and Russia. Prices of animal and livestock products were 'most likely' to increase in the range of +7% to +15%. The price of hay was expected to increase by +14% due to the expected increase in number of livestock, leading to higher demand for hay. Potato price was expected to increase by +15% and sugar beet price by +10% due to increased local demand and exports to Kazakhstan. Since exact calculations of the revenues from fruit and vegetables in kitchen gardens was not available because we asked for an average annual income from these activities and it ranged from 85 to 150 USD per LJF farm, we left this range without the value 'most likely'(the numbers between these values had an equal chance of occurrence). It is important to note that these range refers only to LJF farmers reflecting better export opportunities only in LJF farming system. Barley price was expected to fall slightly by -3% (range -19% to +6%) due to increased imports from Russia.

Prices of agricultural inputs were expected to increase slightly (diesel), moderately (cost of herding services), or substantially (cost of contractors, interest rates). It was expected that legume and cereal yields will slightly increase during the next years due to improved crop rotation. Simultaneously, it was expected that vegetable and sugar beet yields will increase slightly from current low levels due to more widespread use of productivity-enhancing inputs, such as fertilizer or pesticides.

Table 25 Estimated product and factor changes expected from Kyrgyzstan's accession to the EAEU along with current and future adaptation strategies of farmers that collectively may affect farm income

	Affecting	Unit	Change		
			Minimum	Most likely	Maximum
First-order change only)					
Price of cattle/ calf	Revenue	%	-1	+7	+16
Price of milk (cow)	Revenue	%	+4	+10	+33
Price of sheep/ lamb	Revenue	%	+4	+10	+21
Price of horse/ foal	Revenue	%	-9	+4	+7
Price of hay	Revenue	%	-18	+14	+38
Price of potato	Revenue	%	0	+15	+27
Barley price	Revenue	%	-19	-3	+6
Sugar beet price	Revenue	%	+3	+10	+41
Income from kitchen garden*	Revenue	USD	85	-	150
Fuel price	Cost	%	-8	+4	+18
Interest rate (net of inflation)	Cost	%	+29	+33.5	+34
Service of herders	Cost	USD/LU	+5.8	+6.8	9.4
Service of contractors	Cost	%	0	+20	+50
Yield of cereals	Revenue	%	2.3	2.4	2.5
Yield of alfalfa	Revenue	ton/ha[†]	6.46	6.9	7.5
Yield of sainfoin	Revenue	ton/ha[†]	3.0	3.3	3.7
Second-order change (farmers' adaptation strategies)					

	Affecting	Unit	Change		
			Minimum	Most likely	Maximum
First-order change only)					
Lower jailoo farms					
Increase in number of dairy cows	-	LU††	1	1	2
Increase in number of sheep	-	LU††	0.2	0.6	1
Increase in size of legume fodder	-	%	0.39	0.42	0.46
Income from kitchen garden*					
Upper jailoo farms	-				
Increase in number of sheep	-	LU††	0.4	1	1.5
Increase in number of horses	-	LU††	1	0.5	2
Increase in size of legume fodder		%	0.27	0.31	0.32

†Dry matter, metric tons; ††one livestock unit (LU) corresponds to 1 cattle, 0.8 horses or 5 sheep/goat; '0' means no change in price. *refers only to LJF farmers; Adapted from (Azarov et al. 2019).

With regard to second-order changes, results of the farmer survey from the original sample showed that since 2013 about half of the farmers interviewed have adjusted their production systems, i.e., increased their herd size (by 0.7 LU) and plan to do so in the future. No significant differences were found between UJF and LJF farming systems in terms of future improved production practices. Ninety percent of farmers planned a further increase in total livestock by 1.7-3.8 LU due to expected further increases in animal prices (mainly cattle and sheep in LJF, but also horses and sheep in UJF). On average, an increase in herd size as was most likely to be observed in LJF farms at 0.68 LU and at 0.60 LU in UJF. Because of the increase in herds, these farmers also planned to expand the area under legume fodder cultivation – alfalfa in LJF and sainfoin in UJF – at the expense of reducing the area under less profitable barley and wheat. Several resource-rich farmers also mentioned that they plan to invest in farm machinery and contracting services in response to likely changes in farming systems.

6.5.2 Projected net farm income changes in a static scenario

From the Monte-Carlo analysis a statistical probability distribution for the annual inputted net farm incomes for 2018 in both farming systems were derived, assuming the expected changes of prices and factor costs (Figure 23).

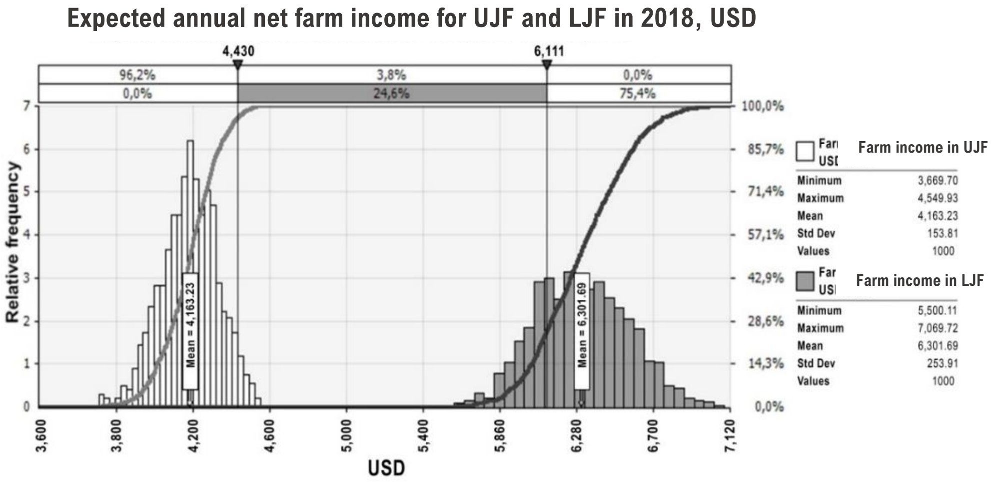


Figure 23 Probability distribution and distribution function of annual net farm income in 2018 for upper jailoo and lower jailoo farms (first-order change only scenario). Adapted from Azarov et al. (2019)

Based on 1000 iterations the simulated 2018 net farm incomes ranged between 3670 and 4550 USD with a mean of 4163 USD for farms in UJF, and 5500 and 7080 USD with a mean of 6302 USD for farms in LJF. Compared to the 2013 net farm incomes of 4430 USD and 6111 USD in UJF and LJF, respectively, this represents a decrease of 5.9% in UJF and an increase of 3.1% in LJF. Only 3.8% of the Monte-Carlo iterations for UJF resulted in a net farm income larger than in 2013, whereas 75.4% of the iterations exceeded the 2013 value in LJF. The S-shaped cumulated distribution functions indicate a generally lower variation in the modelled net farm income in UJF, while the output for LJF showed a higher level of variation.

Sensitivity analyses were conducted for UJF and LJF farm-households to assess the impact of independent variables on net income from livestock and cropping (Figure 24). Changes in sainfoin, meadow hay, barley prices had the strongest impact in UJF. They positively affected crop production income but negatively affected livestock production income. The 14% increase in hay price boosted crop production income but reduced livestock profitability. The 3% decrease in barley price had the opposite effect but was relatively smaller. The increase in sheep/lamb prices had a moderately strong positive impact on livestock income. Other variables showed weak or very weak correlations with expected profits in UJF. Overall, these factors led to a 16% decrease in expected crop income and a 1.4% decrease in livestock income, resulting in a net decrease of 5.9% in total farm income.

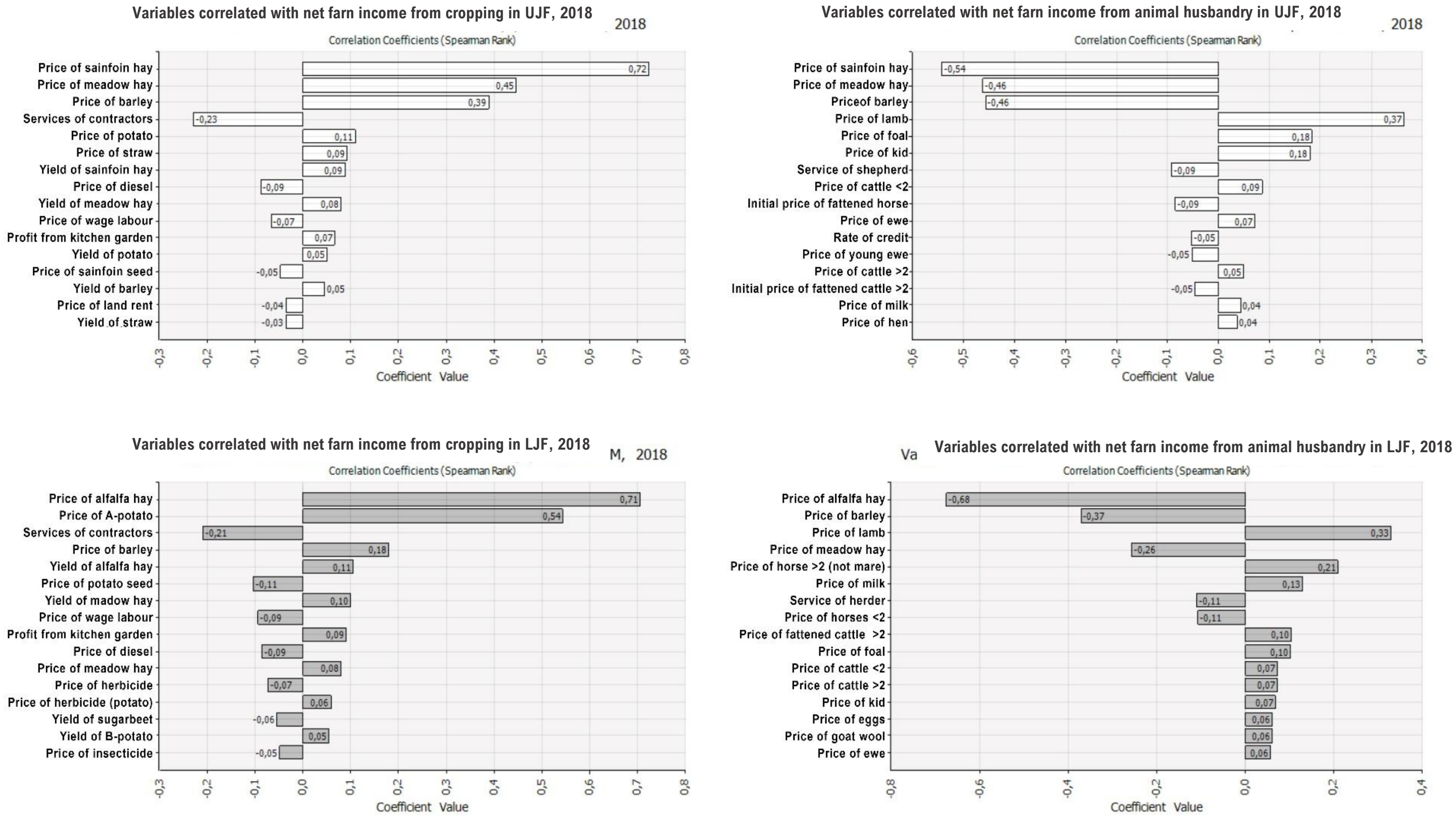


Figure 24 Factors affecting 2018 net farm income for upper jailoo and lower jailoo farms (first-order changes only scenario). Adapted from Azarov et al. (2019)

As in UJF, the expected price increases for alfalfa and potatoes had a strong to moderately strong positive impact on crop income, but at the same time a negative impact on livestock income in LJF. In addition, similar to UJF, expected increases in animal prices had a weak positive impact on livestock income. The influence of other variables on crop and livestock income in LJF was weak or very weak. Overall, these combined factors increased the expected income from crop production by 7.1% while decreasing the income from livestock production by 1.6%, resulting in a net increase in total farm income of 3.1% in LJF farming system.

The results illustrated the constraints under which farmers in the central Tien Shan study site were operating. Due to very limited feed availability and low overall livestock productivity in the UJF area, the increases in prices and market opportunities for livestock did not lead to an increase in farmer incomes. On the contrary, the expected increase in the price of all types of forage was in fact much higher than the expected increase in livestock prices and hence significantly increased the cost of livestock production in this farming system. At the same time, farmers were unable to take advantage of improved prices and market opportunities for sainfoin and meadow hay, as these crops were mainly used on their own farms and were not sold in markets to alleviate the acute shortage of fodder during the winter. The decline in the price of barley, which was one of the few crops whose surplus production was regularly sold by UJF farmers, further reduced their cash income. In addition, rising contractor costs and fuel prices contributed to a decline in the overall income of farmers in UJF. This was mainly because farmers in LJF had two (very rarely three) harvests per year, benefiting from better irrigation facilities and more favorable climate. LJF farmers also faced similar problems as in UJF. The increase in feed costs reduced the profitability of livestock production despite the increase in animal prices because of rising production costs and that feed was largely used on individual farms reducing the benefits that LJF farmers could gain from higher hay prices. Overall, however, farm income increased slightly because LJF farmers produced a greater variety of crops (e.g., potatoes, sugar beets). In addition, cultivated crops were generally more productive (e.g., alfalfa compared to sainfoin), and farmers sold a targeted and larger share of alfalfa hay and other crops to generate income compared with UJF farmers.

Summarizing the results of the static scenario modelling (first-order changes only), expected changes in factor costs and prices lead to only marginal changes in livestock income in the UJF and LJF farming systems. At the same time, changes in factor costs and prices significantly reduce crop income for UJF, while increasing crop income for LJF. These modelling results point to the need for farmers, especially in UJF, to respond to these expected changes by adapting and modifying their land use and production methods.

6.5.3 Projected net farm income changes in a dynamic scenario

In the dynamic scenario (second-order change), UJF and LJF farmers are assumed to respond to expected changes in prices and input costs by adjusting their farm operations and management decisions. The simulated net farm income in 2018 was between 4036 USD and 5521 USD with an average of 4704 USD for farms in UJF, and between 575 USD and 7956 USD with an average of 6781 USD for farms in LJF (Figure 29). Compared to net farm income in 2013, this represents an increase of 6.2% for farmers in UJF and an increase of 10.9% for LJF. The probability of getting simulation results above the 2013 net farm income was 88.2% for UJF and 99.3% for LJF. The results show a slightly lower variation in simulated net farm income in UJF compared to LJF. Sensitivity analysis (Figure 25) showed that hay prices had the strongest impact on crop and livestock income in UJF. These variables had a strong to moderately strong positive effect on crop income and, at the same time, a moderately strong negative effect on livestock income. The expected change in barley prices had a weak positive correlation with crop income and a moderately strong negative correlation with livestock income. The expected increase in livestock prices had a moderately strong positive impact on livestock income. The most important farmer response to the expected price change was the anticipated expansion of sainfoin crops, which had a weak positive impact on crop income. Further adaptation strategies, such as increasing livestock numbers, had only a weak but positive effect on livestock income. Other variables showed only a weak or very weak correlation with expected income in UJF. Overall, these factors together reduced expected income from crop production by 3.6% while increasing income from livestock production by 13.4%, resulting in a net increase in total farm income of 6.2%.

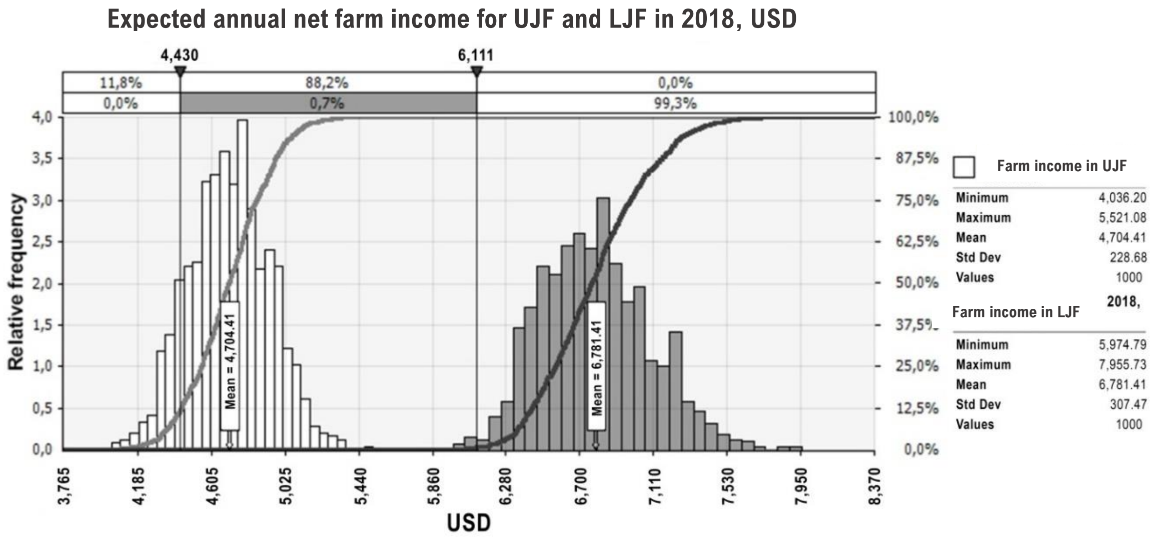


Figure 25 Probability distribution and distribution function of annual net farm income in 2018 for upper jailoo and lower jailoo farms (second-order change scenario). Adapted from Azarov et al. (2019)

The expected price increases for alfalfa, potatoes, and sugar beets had strong to moderately strong positive effects on crop income in UJF. At the same time, alfalfa and barley prices had strong negative and weak negative correlations, respectively, with income from livestock production. In addition, the expansion of alfalfa in response to expected price and factor cost changes, as well as the expected change in sugar beet prices, had a weak positive effect on crop income. Moreover, the expected increase in meadow hay prices had a weak negative effect, while the expected increase in animal prices and the planned increase in livestock numbers had a weak positive effect on livestock income. The impact of other variables on income from crop and animal production in LJF was weak. Overall, together these factors increased the expected income from crop production by 23% while decreasing the income from livestock production by 3.2%, resulting in a net increase in total farm income of 10.9% in LJF.

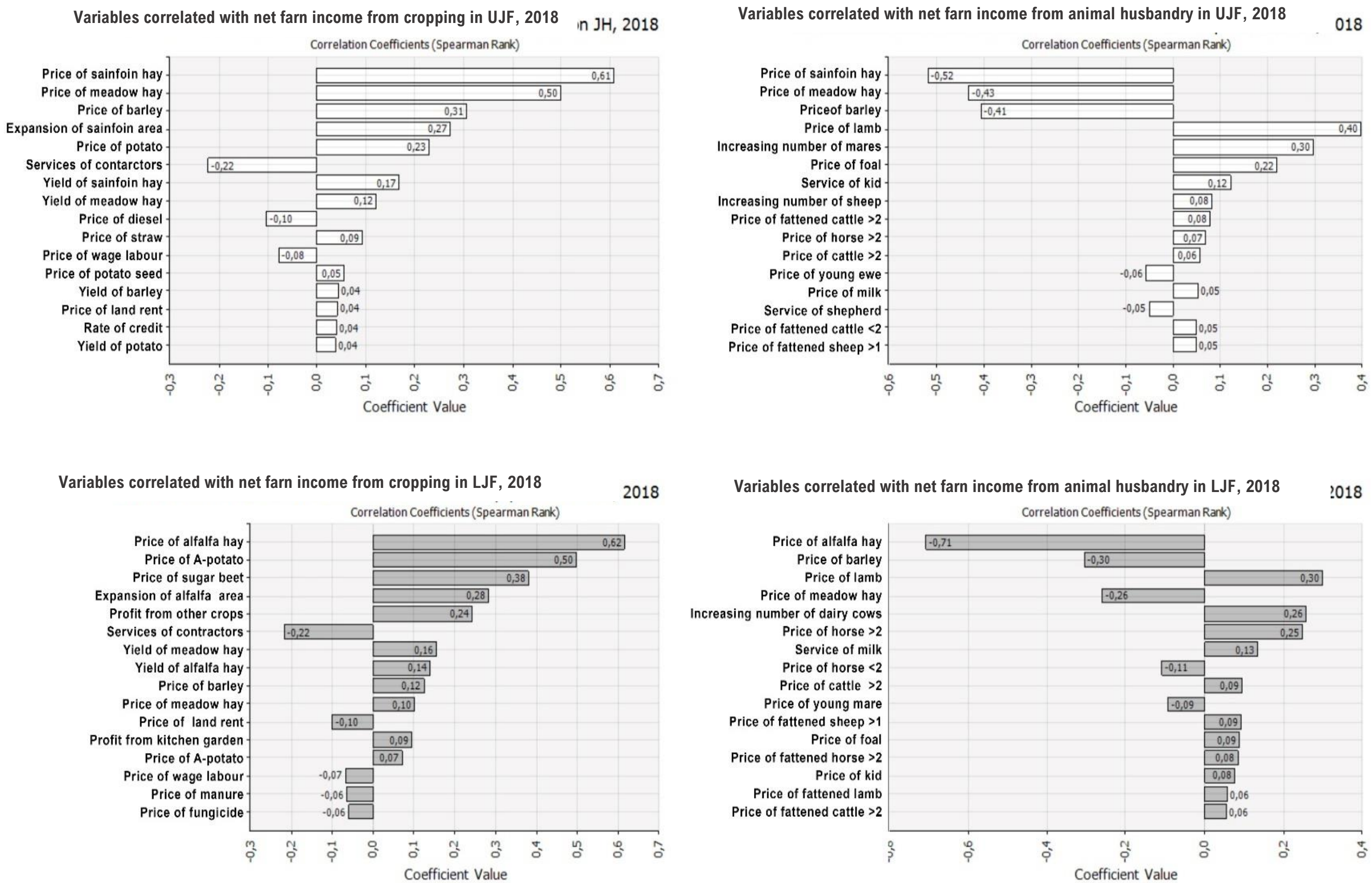


Figure 26 Factors affecting 2018 net farm income for upper jailoo and lower jailoo farms (second-order change scenario). Adapted from Azarov et al. (2019)

Overall, simulation results of the second-order change scenario indicate increases in net farm incomes in both farming systems as a result of increases in crop and animal prices and adjustments in farm management and production methods. The effect of these changes was different in the two farming systems. In UJF, the increase in total net farm income was mainly due to changes affecting the profitability of livestock production, while the increase in net farm income in LJF was mainly due to higher profitability of crop production. Processed products (e.g., cheese, mare's milk) did not contribute significantly to farm income in either farming system despite growing markets or higher prices for these products.

Finally, these results indicate that adjustments in the smallholder land use and production methods are required to increase farm income. The change of prices and factor costs expected from Kyrgyzstan's accession to the EAEU alone did not substantially increase farm incomes. The adjustments farmers proposed to their current farm management in response to these changes of prices and factor costs will essentially contribute to a transformation of their largely subsistence-oriented farms to a more market-oriented production system, already observed in selected areas of lower jailoo farms where farmers switched from fodder production for their animals to cultivation of potatoes, sugar beets, haricot beans, or green peas in response to demands by foreign traders. For farmers in UJF, a moderate increase in livestock numbers and livestock marketing along with an expansion of fodder cultivation is suggested to increase the profitability of livestock production. A detailed farm income simulation is given in the following sub-sections in the Discussion.

7. Discussion

This section discusses the methodological aspects applied in the differentiation of farming systems and subsequently answers research question 5 on possible future pathways for identified farming systems in the south-western and central Tien Shan based on the results of analysis of their characteristics i.e., agricultural production, non-agricultural activities, overall livelihoods, and farmers' objectives.

7.1 Methodological aspects of farm-household typology

Although the classification approach we propose using multivariate statistical methods to identify farm types is theoretical and not new, it is, however, a fundamental step for portraying socio-economic conditions of farmers and decision-making. The two slightly different methods presented here, i.e., the *K*-means and the hierarchical agglomerative method, have dealt with the question of establishing typical farming systems using empirical information on farm characteristics, and there is no reason to favor one or the other in farm delineation. Both methods are equivalent and applicable in clustering, and it is more important to consider the selection of classification variables that are relevant to the purpose of the study and the low correlation among the selected classification variables (Madry et al. 2013). The considerable variation that we observed in winter forages can be attributed to the divergent feeding strategies that farmers employ, even within the same group. As pointed out by Kuivanen et al. (2016), homogeneous farming systems often exhibit notable differences in production practices, yields, and income levels as a result of disparities in access to inputs. These differences imply that farming systems, especially in livestock production, can be classified into distinct farming subsystems, as posited by Hardiman et al. (1989). However, the necessity for further differentiation depends on the research objectives and is often utilized in farming systems that are already classified to enable a more precise analysis, as advocated by Gebauer et al. (1986). It is essential to note that a high degree of variation within farming system groups is inevitable and almost impossible to eliminate entirely (Riveiro et al. 2010; van de Steeg et al. 2010). Despite the considerable variability of forages, we contend that categorized farming systems are adequately described. However, we also acknowledge that a further division into farm subsystems based on this criterion is a feasible approach.

So far, no such classification has been performed throughout Central Asia. The official delineation of peasant farms based on farm size and the omission of further socio-economic and agroecological parameters dilute the diversity of smallholder farms and do not reflect the characteristics of cropping and livestock rearing systems and other income-generating activities (Liechti 2002; de la Martinière 2012). Firstly, our descriptive statistics differ significantly from the official data on peasant farms even on the key variables for the division of peasant farms, i.e., size of the arable land. According to NSC (2021) the size of peasant farms averages 2-3 ha, in our system it averages 5.3 ha in agropastoral areas and 0-0.12 in the silvopastoral farming system. The same applies to the number of livestock, which averages 3 LU per peasant farm according to NSC (2021), but in our system the values ranged from 4.5 to 16.3 LU. Furthermore, the shares of cultivated crops differ strikingly from the conventional data (FAO 2020; NSC 2021); in agropastoral farms fodder crops dominated, while cereals (wheat) dominate in the official statistics. In silvopastoral farm-households, cultivation of crops occurred only in kitchen gardens due to unavailable arable lands. Moreover, we give an analysis of the cropping systems (type of crops, yields, incl. NTFPs) and livestock systems (animal types, grazing management), which implies a detailed description of labour inputs for all of these operations, as well as a calculation of the economic performance of each production system, which is important to identify different categories of farms endowed with different means of production (Diepart & Allaverdian 2018). The inclusion of agroecological parameters, defined by climate, topography, and land cover that influence the land use of farmers (FAO 1996) gave a division of farming systems - e.g., in 'village elevation' two different agropastoral farming systems where the cropping and livestock systems were different due to climate conditions; and in silvopastoral farming systems, income from NTFPs which highly related to forest land (land cover) led to delineation of distinct farm-households that were dependent on forest NTFPs differently. Finally, in the official delineation of smallholder peasant farms, off-farm activities are not considered, although our results show that this source of family income was substantial. We integrated off-farm and non-farm activities to understand the role they play in their interaction with farming activities, how they complement the farming income as proposed in similar farm typology studies (e.g., García-Martínez et al. 2011; Kuivanen et al. 2016; Diepart & Sem 2018).

Most studies on livestock-based and mixed farming systems have focused on creating typologies to address a particular research problem. The majority of these studies take the production system into account, as farming system function and production decisions have significant impacts on the farm economy and its environmental impact (Andersen et al. 2007; Castel et al. 2010; Riveiro et al. 2013; Kumar et al. 2019; de Glanville et al. 2020; Habanabakize et al. 2022). Additionally, distinct characteristics of livestock and mixed farming systems are determined by specific opportunities and constraints, which in turn are shaped by various factors beyond the household scale, such as agroecological, elevation, climate, and soil characteristics (van de Steeg et al. 2010. Tittonell et al. 2010; Kuivanen et al. 2016; Diepart & Sem 2018). To better understand the diversity of social, technical, and economic characteristics of agropastoral and silvopastoral households and their agroecological environment in Tien Shan mountains, a categorization of farming systems based on both on-farm criteria (such as the size of cultivated land and herds) and external factors (such as elevation, forest cover and the possibility of non-timber forest product collection, off-farm income) was compiled. Although typologies are typically applicable within the context in which they are developed, comparative categorization methodologies offer avenues for their further advancement (Köbrich et al. 2003; Carmona et al. 2010). In most livestock-based farming systems in mountainous regions of developing countries, small-scale farmers constitute the dominant land use patterns and exhibit a diverse range of heterogeneous livelihood strategies. This highlights the significance of considering the local context and diversity when developing interventions and policies aimed at enhancing agricultural productivity and livelihoods in mountainous areas (Bernués et al., 2011;). Moreover, there are various similarities between the challenges faced by mountainous regions, particularly in Central Asia, such as difficult terrain and long distances to markets, seasonal scarcity of forage, and degradation of natural resources (pastures, forests) due to unsustainable resource management. These challenges are also encountered in other mountainous regions of Central Asia (Kerven et al. 2012, 2016; Xenarios et al. 2019; Sidle et al., 2023) northwest China (Li et al. 2008), northern Pakistani Hindu Kush-Himalayas and Nepal (Tulachan et al. 1999; Maltsoglou & Taniguchi 2004; Sharma et al. 2006; Hameed et al. 2022), highlands of Africa (van de Steeg et al. 2010; Slim et al. 2012; Gebiso Challa et al. 2019; de Glanville et al. 2020; Musafiri et al. 2020), and the south American highlands (Carmona et al., 2010; Etter & van Wyngaarden 2000). In these studies, apart from farm size (including pasture and herd size), the typical criteria used to classify small agropastoral farming systems in mountainous areas included elevation and agroecological conditions. For instance, in the arid and semi-arid regions of Pakistan, India, China, Nepal, and African countries, farms situated at higher elevations placed greater emphasis on livestock production and operated on vast rangelands, highlighting livestock farming as the principal livelihood strategy in highland conditions. In the middle highlands, a mixed farming system dominates, where animal husbandry and crop production are the primary sources of income. However, as the altitude decreases, irrigated crop production becomes increasingly prominent and animal husbandry plays a secondary role (Steinfeld & Mäki-Hokkonen 1997). This trend is also observed in agropastoral systems in the Central Tien Shan, where lower jailoo farms operate more intensively and productively on cultivated land, including better irrigation practices that allow increased fodder production. Moreover, these farms cultivate a more diverse range of crops in comparison to upper jailoo farms, highlighting the impact of agroecological conditions on farming practices.

The agroecological zone is also a component of the agrarian system and is not limited to agricultural land use; it can also consist of forests and accompanying pastures, i.e., a combination of several land uses including crop cultivation, harvesting of forest timber and NTFPs, and grazing (Diepart & Allaverdian 2018). Studies of the typology of farming systems in forested areas in the Andes, Africa, and Asia document deforestation and the formation of new agrarian cover systems in southern Chile and Kenya (van de Steeg et al. 2010; Carmona et al. 2010; Etter & van Wyngaarden 2000). In these studies, the key elements in differentiating farming systems are related to the drivers of land-use change Usually the blame for much of the deforestation in developing countries is placed on smallholder agriculture, either directly or through logging activities which open forests. This contributes to further land cover change or conversion and the expansion of smallholder farming and livestock production because the difficult survival conditions in rural areas are exacerbated by the lack of productive alternatives (Carmona et al. 2010). Despite logging being prohibited in the southwestern Tien Shan forests, our research revealed that the growing pressure of livestock on the forest pastures is acknowledged by both forestry workers and farmers. This pressure has resulted in a decrease in forest density and has endangered certain forest species (Borchardt et al. 2010).

Farm categorization in more developed mountainous livestock systems of Europe is often aimed at refining and complementing a pre-existing typology which gives a greater description of the diversity of their farming activities and changes at farm level (Madry et al. 2010). Classification studies often include quantitative variables related to farm size (mainly land area) and herd size (significantly larger compared to small farming systems in developing countries) along with animal specialization, such as sheep, goats, and dairy cows in a combination of farm management and animal production. Variables related to the availability of different animal species (indicating multiple farmer activities) are also often used (D'Angelo et al. 2000; Usai et al., 2006; Gaspar et al., 2008, 2011; Castel et al., 2010; Ayantunde et al. 2011; Riveiro et al. 2013; Bombaj et al. 2019). In our typology, a similar approach would also be possible, for example in the agropastoral farming systems in central Tien Shan there were individual clusters which could be folded into sub-clusters (see dendrogram Fig 17) specializing in individual animals or in intensive crop production (e.g., fattening sheep and bulls in upper jailoo farms , and horticulture or vegetable production for sale in lower jailoo farms). The number of such farmers is likely to increase as shown by the survey of agro- and silvopastoral goals of farmers in our study area (cf. 6.3.3).

The variable 'off-farm income' has been found to be significant in much of the research on the typology of livestock farming systems (Goswami et al. 2014; Diepart & Allaverdian 2018). In more developed farming systems, the availability of workers and the degree of involvement of family members in off-farm activities are associated with the possibility of earning from such activities when free time is available (Hardiman et al. 1990; Bernués et al. 2011; Riveiro et al. 2013; Pacini et al. 2014). However, in the challenging agroecological conditions of the highlands, shortages of agricultural production and crop failures, such as non-timber forest products, are common, which forces rural households to diversify their livelihoods by generating income from off-farm activities (i.e., off-farm income). Depending on the types of households, some rely on migration or are restricted to seasonal work as wage laborer in off-farm activities in villages or nearby towns (Kuivanen et al. 2016). Distance to market can be used as a determinant of off-farm income (Hameed et al. 2022) and traveling outside the community to urban areas not only provides diversification of income but also access to new information and technology, and the income generated can be invested in the farm (Murzakulova 2022). In our study area, sources of off-farm income varied, as is the case in other developing countries, and included remittances from extended family members earning in urban areas or abroad. In most households in all areas, at least one family member worked temporarily or permanently off-farm, and in about half the cases, family members were engaged in permanent off-farm activities, especially in the silvopastoral farming systems in southwestern Tien Shan.

As the typology of farming systems and all subsequent analysis help to identify different categories of farm families endowed with different means of production and differently involved in achieving livelihood goals. This provides insights into the social, technical, and economic situation of different categories of farmers, enabling recommendations to be made to address their specific problems and development trajectories (Diepart & Allaverdian 2018).

We believe our study substantially advances the classification of smallholder peasant farms in Kyrgyzstan. The approach proposed here can be also particularly useful in research, especially in developing countries where farm typologies must be created from scratch (Köbrich et al. 2003). Although many researchers note the general challenges facing smallholder production systems and resource degradation (Kasymov, Undeland, Dörre, & MacKinnon, 2016; Sabyrbekov, 2019), the identification of distinct farm types presented in this doctoral study can be used as a basis for subsequent discussions on constraints and opportunities for agricultural development in each farming system. In the following sections, the major constraints, and opportunities for silvopastoral and agropastoral farming systems are discussed.

7.2 Constraints and opportunities for silvopastoral farming systems in the south-western Tien Shan mountains

The lack of opportunities to harvest NTFPs was identified as a major problem affecting livelihood strategies in local silvopastoral farming systems. The degree of exposure to NTFP failure (especially walnuts) for a particular group of farmers can be determined by their revenues from harvesting forest products. For instance, HFD and MFD farmers were more dependent on income from NTFP harvesting because the share of NTFP in total family income was significant (45.3% and 14.2%, respectively). We are not advocating that poor households collect mainly other NTFPs and fewer walnuts, as indicated in other studies (Schmidt 2005, 2007). All households collected NTFPs if they had available labour and permission to collect

NTFPs (Dzhakypbekova et al. 2018). HFD farmers had access to more NTFPs (especially walnuts) with the highest yields because they had leased forests and had unrestricted rights to harvest walnuts and wild apples (Agrolead 2016). MFD farmers had less access to harvesting and less income from walnuts compared to HFD because of the lack of leased forests, which also applies to farmers from Kara-Alma and Arkyt villages due to harvesting restrictions and the conservation status of forests. LFD farmers had the least access to collect NTFPs and the smallest income from NTFPs compared to the other farm types, mainly due to the prohibition or restrictions on the collection and lack of walnut forests. Nevertheless, collection of prohibited NTFPs (e.g., mushrooms, hawthorn) often occurs in all farm types despite the restrictions. Thus, there appears to be an increase in the collection of protected NTFPs during stressful times (Schmidt 2013). The collection of banned NTFPs was recognized by nature reserves and forestry officials, and it is obvious that prohibitive measures are not sufficient to stop the collection of such NTFPs (Shigaeva & Darr 2020). Notably, none of the surveyed farms that collected NTFPs processed these products for sale (e.g., by drying and making jam), which implies the sale of NTFPs without added value (Agrolead 2016).

According to HFD and MFD farmers, good walnut harvests occur every 2–3 years, as noted in other studies (Schmidt 2005, 2013; Dörre & Schütte 2014; Shigaeva & Darr 2020). Consequently, all silvopastoral families have seen increases in the number of livestock to compensate for the fluctuating NTFP revenues, particularly in MFD farms. Livestock has become a savings account on farms in our study area, which is typical of mountain farmers throughout Kyrgyzstan (Steimann 2011; Kerven et al. 2012, 2016; Anarbaev 2021). The main constraint in animal husbandry was the lack of winter fodder, which was in short supply in all farm types observed. This is not surprising as most silvopastoral farmers have no arable land (unlike other parts of the country) where fodder crops can be grown, and the available forest meadows did not provide sufficient fodder (Borchardt et al. 2010, 2011; Cantarello et al. 2014). Therefore, more than 90% of all fodder was purchased by farmers (often at a high price) and this was the only factor limiting farmers from further increasing their herds. To save fodder, farmers tried to keep cattle on forest pastures for as long as possible, including during winter. In all farming systems, livestock became emaciated livestock became emaciated from winter to mid-spring due to a lack of roughage in their diet (Azarov et al. 2019, 2020; Yang et al. 2022). Grazing in autumn and spring has a negative impact on the forest soil, particularly in wet areas (Kulikov & Schickhoff 2017). More than half of the interviewed farmers in all types admitted that the increase in livestock has a negative impact on the forest. This was confirmed in a study that found traces of animal damage on almost every wild apple tree and other fruit trees (Orozumbekov et al. 2015). Although the grazing system has generally remained the same, with remote and village pastures allocated for grazing during specific periods (Schmidt 2007), there is still no clear grazing management in these forest pastures that are developed by a nature reserve and forestry staff. There is either a ban on grazing in the forest areas or forest pastures are specifically designated. Local experts (nature reserve and forestry staff) note that there are no specific norms and regulations which can be used to introduce quotas on livestock numbers and pasture rotation practices to reduce grazing pressure like, e.g. 'pasture committees' in other regions of the country (Shikhotov et al. 1981; Mestre 2019; Umuhoza et al. 2021). It is obvious that bans on livestock grazing in unauthorized areas of nature reserves are the only current measures preventing pressure on forest pastures; however, these do not consider the importance of livestock for silvopastoral family livelihoods, especially during times of low NTFP harvest (Cantarello et al. 2014; Wilson et al. 2019). Therefore, improving forest pasture management and controlled grazing in the study villages are necessary to ensure sustainable use of forest pastures, biodiversity conservation, and soil protection. Some studies from other silvopastoral communities have shown the positive effects of proper grazing on forest biodiversity (Wilson et al. 2019). Other studies report that for silvopastoral households, fodder cultivation (including fodder trees) and stall feeding can be a way of combining livestock production and forest conservation (Hardy et al. 2018).

According to farmers, remittances from abroad have become a more profitable source of income in comparison to incomes from animal husbandry and NTFP collection. During times when NTFPs could not be harvested (particularly in MFD and HFD), migration of family members, mostly to Russia, increased. In LFD and MFD farms, the share of income from the private business was quite high due to the recent increased involvement of local silvopastoral families in tourism (e.g., hotel services, cafés, horse rentals). Due to natural tourist attractions (e.g., Sary-Chelek Lake, Padysh-Ata pilgrimage site) as well as the improvement of roads to these destinations, the number of tourists visiting such places has increased (NSC 2018; Jenish 2018). Analysis of GMs showed that MFD farmers with the largest herds, in fact twice as large compared to the other two farming systems were less productive per LU and had the greatest negative impact on forest pasture conditions. Farmers could not sell skinny animals and the mortality rate went up, making animal husbandry riskier. This indicates that for silvopastoral farming systems, especially for MFDs, advisory services are needed to introduce efficient livestock production (Borchardt et al. 2011; Azarov et al. 2020).

Although most farm types note that their livelihoods will remain static, there is strong evidence to strengthen their farming and non-farming activities. In reference to off-farm income, we are not referring to migration, although migrant remittances are currently an important livelihood strategy. In the long run, this can lead to a high dependency on remittances, non-return of migrants, and breakdown of the family unit and, subsequently, labour shortages, as confirmed in other studies in agropastoral communities (Schmidt & Sagynbekova 2008; Schoch et al. 2010; Zhunusova 2017; Sagynbekova 2017; Zhunusova & Herrmann 2018). These studies also note that in most cases, migrant remittances are mainly invested in livestock production (i.e., increasing the number of livestock), which may further increase pressure on already degraded pastures. These findings are applicable to silvopastoral families because migration has become a more profitable source of income, given that many farms have increased and are planning to increase livestock holdings.

For farmers of all systems, the importance of income from livestock is indisputable, and it is necessary to introduce sensible pasture stewardship as well as adequate supplies of available forage, thus reducing pressure on forest pastures. There is a tendency in all systems to generate income from off-farm activities. Current efforts to develop sustainable rural tourism, therefore, are promising strategies and should be continued in the future. Such efforts should primarily be directed to farms of MFD and LFD, which possess good prospects for tourism development. This coincides with recommendations for agropastoral families in other regions of the country (Sabyrbekov 2019). In addition, given the importance of income from NTFP collection, particularly for HFD and MFD households, efforts to increase local value added through NTFP processing, direct marketing, and other approaches should be primarily targeted at these farmers. Training and the introduction of processing technology, along with the establishment of markets, is an obvious need (Jalilova & Vacik 2012; Jalilova et al. 2012). Although there have been numerous projects in the past to support the development of local small and medium-sized food enterprises (SMEs), most of these have ceased due to discontinuation of funding, indicating the importance of longer-term support. Finally, as MFD farmers were the most involved in livestock production and their profitability was much higher compared to the other two types, efforts to improve pasture management as well as improving the supply of available forage should be focal points. In addition, beekeeping has good potential for development for all types of farms; the analysis shows that income from honey production is very high and most importantly this activity does not negatively affect forest pastures as does livestock production.

7.3 Constraints and opportunities for agropastoral farming system in the central Tien Shan mountains

The UJF farms were distinguished from LJF households by their larger arable land areas on which fodder crops were planted. Due to insufficient irrigation facilities, as well as more severe climatic conditions, farmers in UJF obtained lower overall crop yields. Moreover, there was little use of potentially productive inputs, such as fertilizer (only 2% of farms) accompanied with low levels of mechanized soil cultivation that would augment crop production (Kerven et al. 2011; van Berkum 2015; FAO 2016).

Given the importance of livestock production in UJF, livestock can be considered as saving mechanisms, representing not only subsistence but also financial security (Martinière 2012; Steimann 2011), thus an important consideration is sufficient fodder supply. To obtain higher fodder yields, support is needed to establish and upgrade irrigation facilities, road infrastructure into remote areas (fallow), and services of agricultural contractors. At the production level, farmers need to modify their farm management, e.g., increasing use of productive inputs, such as fertilizers (both mineral and manure), increasing legume fodder cultivation, higher quality seed sources, more efficient cultivation techniques, and better irrigation systems. Some new practices and technologies for sainfoin cultivation in the highlands of Kyrgyzstan have been introduced by WOCAT (Akramkhanov 2016; Asanaliev & Usubaliev 2011) within the project 'Prevention and Mitigation of Land Degradation' through demonstration studies, distributing agricultural equipment, and supporting individual smallholders via training and information. Results revealed that farmers in focal areas at elevations of 2200-2300 m a.s.l. obtained higher yields of sainfoin due to introducing improved cultivation practices. These sustainable practices are of particularly important because of continuing growth in livestock herds, not only in the study area but throughout the country (Mogilevskii et al. 2017; Sabyrbekov 2019) and increasing pressure on pastures due to overgrazing (e.g., Robinson 2016; Kulikov & Schickhoff 2017). Sufficient fodder supplies during and after winter allow farmers to keep animals in good condition and sell them during this time when prices are significantly higher as farmers usually market animals from mid-summer until late autumn at lower prices when animals have gained weight in pastures (Tilekeyev et al. 2016). In addition, increased fodder stock allows farmers to keep animals indoors longer and prevents pasture degradation, especially during the wet early spring (Isakov & Thorsson 2015; Kulikov et al. 2016; Tagaev 2018).

LJF farms are characterized by livestock and crop production together with income-oriented fodder and other crops (e.g., potatoes, sugar beets, haricot beans). These farms exhibit a comparatively higher level of mechanization relative to UJF farms, mostly relying on machinery for farm operations supplied by agricultural contractors in the region. Land utilization was significantly more productive on LJF farms compared to UJF farms, even though LJF farms are smaller. Farms in LJF can further increase cash crop areas to benefit more from crop production given the existing advantages of their irrigation facilities, warmer climate, higher soil fertility, and better road infrastructure and market access. This indicates that LJF farmers can grow more crop species due to better natural conditions, which support food security and nutrition (e.g., diverse diets). Moreover, an analysis of GM from crop and livestock production showed that on the LJF farms crop production was more profitable than livestock production, suggesting a move towards selling more crops rather than feeding the produced feed to the herd. This also demonstrates the need for advisory services for LJF farmers to learn how to calculate the benefits and costs of both livestock and crop production.

Though the average number of livestock in LJF was almost equal to average herd size in UJF, the animals in LJF were typically in better condition because of the longer pasturing period and comparatively better fodder supply. However, similar to UJF, but to a lesser degree, animals in LJF suffered from a lack of fodder during cold months due to inadequate production of winter feedstuffs (Borchardt et al. 2011). In addition, LJF had higher average fodder costs per livestock unit despite a longer pasturing period caused by using higher-quality fodder (legume hay and concentrates). Given that livestock production was also substantial for LJF, and the insufficient supply of feed forced farmers to use pastures intensively during spring and autumn contributing to pasture degradation (Robinson, 2016), the simple expansion of legume crops (alfalfa) cannot ensure sufficient fodder supply in LJF as well as in UJF. Moreover, LJF farmers in this cluster already maximized the cropping area of alfalfa due to a proportionate reduction in areas of wheat, barley, and other crops in recent years. Silage making is now almost entirely neglected by smallholder farms (Fitzherbert, 2006). However, the cultivation of the crops for silage production could be a solution and community silage production may be an option (Ahado 2021). Increasing demands for animal fodder and cash crops can act as an incentive for some farmers to further diversify their operations and/or to specialize rather than to increase their own herds, thereby decreasing their dependence on subsistence production. This indicates the need to conduct agricultural extension outreach to advise and guide farmers in their attempt to specialize agricultural production. Other studies have reported similar findings in the region (Lerman & Sedik 2018, Sabyrbekov 2019).

Resource limitation can induce a shift in livelihood strategies, e.g., towards a higher dependence on off-farm income (Sabyrbekov, 2019; Schoch et al. 2010). This may affect decision-making, farming practices, and certainly household priorities for investing cash and labour resources (Schoch et al. 2010). The income from the non-agricultural activities was observed in many farms (>90%) and constituted a substantial part of their income (52% in UJF and 42% in LJF) derived from pensions (the older household members retired from non-farm jobs), reflecting the lack of private sector and business employment opportunities in both farming systems, particularly in UJF. Although the income generated from farms often flows partly into farm production investments, these may change the production methods/farming practices in a farm-household, e.g., less labour demanding crops and livestock production (Shigaeva et al. 2007) rather than the structure of farm typology in the study area. According to farmers, the dependence on non-agricultural income increased in recent years, particularly remittances (Chandonnet et al. 2016; Sagynbekova 2017). This is not surprising as off-farm income contributed one-third of the total family income, reflecting an important livelihood strategy in both agropastoral farming system types.

Results of Monte Carlo simulations illustrate the uncertain factors that most affect farm incomes, which in turn help to improve farm revenues. For example, to benefit from increasing prices for livestock and agricultural products, farmers need to further adjust and modify their farm management, which can include the expansion of cash crop cultivation in LJF or an increase of herd sizes along with an expansion of fodder cultivation in UJF. Schoch et al. (2010) and Sabyrbekov (2019) found that increasing incomes led to production diversification, e.g., increase in livestock numbers. Given the substantial importance of livestock production in both farming systems and increasing pasture degradation in Kyrgyzstan (e.g., Robinson, 2016), an important consideration is to what extent herd size increases can be supported by pasture conditions without degrading pastures. Simultaneously, increasing demand for animal fodder and cash crops can act as an incentive for some farmers to further diversify their operations and/or to specialize rather than to increase their own herds, thereby decreasing their dependence on subsistence production. Other studies have reported similar findings in the region (Lerman & Sedik 2018, Sabyrbekov 2019). Furthermore, results clearly indicate that LJF farmers benefit more from the expected changes of prices and factor costs than farmers in UJF. This is not surprising given the existing differences between both areas regarding their remoteness, climatic conditions, and soil fertility. Farmers in high elevations are additionally disadvantaged by the general lack of road infrastructure and market access; poor irrigation facilities and livestock watering points; and the limited availability of extension and veterinary services. Therefore, farmers in UJF can only make slight adjustments to their production methods due to their limited resources in terms of productive land, capital, or knowledge and information. Our findings can, thus, also be understood as a plea to policymakers and development practitioners to intensify their efforts to promote rural development of mountain regions to alleviate the socio-economic disparities between various parts of Kyrgyzstan. This finding also agrees with the widening gap reported between policymakers and smallholder pastoralists (Kasymov et al. 2016).

The lessons derived regarding the required adjustments of farm management and production methods and the dissimilar benefits derived by farmers in high versus middle-elevation systems, considering uncertainties that affect rural areas, may prove beneficial for other countries in the region. As a practical contribution, our analyses can provide the following useful insights and guide policy making in Kyrgyzstan and beyond: the relatively small scale of farm operations and related inefficiencies suggest that significant improvement potential lies in consolidating the farming structure by helping smallholder farmers to cooperate in agricultural and livestock production, marketing, investments in infrastructure and technology, and/or farm expansion to achieve more competitive scales. While the establishment of cooperatives and larger-scale private farms is difficult in the short term due to various historical, economic, and socio-political reasons, it remains an important strategy of future agricultural policymaking. Equally important are investments to ensure the quality and safety of agricultural products, particular livestock, and meat products, to export these to third-world countries. Kyrgyz producers have difficulties to export agricultural products to EAEU markets due to numerous impediments and barriers. In 2015, for instance, Russia and Kazakhstan imposed a ban on Kyrgyz meat imports because of the occurrence of epizootic diseases, and the temporary import ban for potatoes to Kazakhstan due to detection of nematodes (*Globodera rostochiensis*) in 2016. Towards this objective, several structural improvements need to be implemented in the Kyrgyz livestock sector from farm to fork, which includes the provision of improved extension and veterinary services to farmers, more stringent veterinary and sanitary controls, upgrading of laboratory equipment and staff training, and improving the hygienic conditions in slaughtering and meat processing. Such improvements could foster the export potential of the sector to international markets, thereby increasing income for Kyrgyz farmers as noted by other researchers (Mogilevskii et al. 2014, Tilekeyev et al. 2016) .

8. Conclusions

8.1 Fullfilment of the thesis objectives

Addressing the stated objectives of this doctoral study, the following conclusions can be drawn:

- The developed and implemented classification methodology yielded distinct smallholder farm classes that can be appropriately interpreted and utilized. The utilization of a multivariate classification approach confers significant benefits compared to a classification solely based on farm size and legal status. Such an approach not only considers the diversity among size categories, but also incorporates agroecological conditions and the socioeconomic context of the farms. Moreover, the methods employed in this study can be adapted to specific classification goals in diverse mountain regions by employing different variables as required.
- The multivariate analysis facilitated the delineation of farms into five clusters that provide a more comprehensive understanding of the characteristics and types of strategic livelihoods for mountain farm groups within each cluster. Results provide relevant information on farming systems in mountain areas and fill the current gap in typology delineation of farming systems in Kyrgyzstan, recognizing that such gaps also exist in many other mountain farming systems worldwide.
- The results of the farm income simulation showed that there was little difference between the static and dynamic scenarios with simulated prices and factor costs. This indicates that potential adjustments in the farmers' production method were not significant. Continuous adjustments in land use and production practices of smallholder farmers are required to improve farm income. National agricultural and economic policies should aim to improve the farming conditions by encouraging further professionalization of the farming sector through education, infrastructure development, consolidation of agrarian structures and improved management of food quality and safety.
- Lack of access to income from NTFPs and off-farm activities affects clusters differently and leads farmers to pursue livelihood strategies oriented to livestock production, which in turn affects the sustainability of forest resources and potentially degrades the land. To improve livelihoods in clusters in a sustainable manner, it is necessary to identify challenges and opportunities within the cluster context and recommend appropriate sustainable interventions.

8.2 Limitations of the study

A multivariate analysis led to two types of agropastoral farming systems. Our first attempts at cluster analysis with a slightly different set of classification variables led to a division of farms into three categories of resource rich, medium resource, and poor; or into categories: rich crop producers, crop producers, and livestock producers (and their variations from rich to poor). We considered that such differentiation into these categories does not really require a multivariate analysis and over-simplifies agricultural/policy interventions/suggestions in their farm production system. Despite the fact that only two types were chosen at the conclusion of this study, t-tests showed a significant difference between the classification variables, and we described the differences in resource endowments and farm production systems sufficiently to provide recommendations for each type to improve their agricultural production. This classification gives a more detailed understanding of smallholder farms than the official categorization, which has been emphasized in the thesis.

The primary aim of this study was to develop classification methods for mountain farming systems in Central Tien Shan. However, due to the reliance on data collected from a survey conducted in 2014, it became apparent that a classification based solely on agropastoral systems would be insufficient for this doctoral study. Therefore, to enhance the breadth and depth of our investigation, we expanded the scope of our research to encompass silvopastoral farming systems in southwestern Tien Shan. However, in light of the necessity to acquire funding for additional research, the delay in securing funds, and the subsequent late receipt of funding for a survey conducted in southwestern Tien Shan region resulted in a significant temporal gap between the studies in our particular case. Nevertheless, by employing multivariate analysis to cluster these additional farming systems, our research findings were able to be enriched and contrasted, enabling us to provide a more robust data set for analysis. Ultimately, through this approach, we were able to achieve a more comprehensive understanding of the diversity of mountain farming systems.

We acknowledge that the age of the data we collected on agropastoral farms in the central Tien Shan region in 2014 may elicit criticism of its relevance in the present day, which is a valid concern. However, we would like to emphasize that Kyrgyzstan is still considered a developing country, and unfortunately, the socio-environmental situation in rural and remote mountainous areas has remained relatively unchanged since the time of our initial data collection. As such, we presume that the agricultural production of agropastoral farmers has not undergone significant transformations in the intervening years. Additionally, data collected in 2016 from a subset of 20 farmers from the original sample revealed minimal changes in production over a three-year period. Despite the potential criticism of outdated data, we maintain that our study remains significant and original, as comparable data have neither been collected before nor after 2014. Furthermore, our study presents a comprehensive portrayal of production systems and household economic outcomes, encompassing interviews with livestock and crop farmers, and including off-farm income and resource bases. Additionally, we believe that our study can offer valuable insights into the development of smallholder agropastoral households during the intervening period. Finally, by supplementing our data on agropastoral systems with results from silvopastoral households, we have constructed a more robust data set for our analysis, thereby enhancing the relevance and value of our study.

Shortcomings in Monte Carlo simulations include high dependence on expert estimates in the absence of ex-post data, as well as the size and composition of the expert panel, which we tried to address by assembling the best expertise available from leading national institutions in public administration, academia, and the livestock sector. Our restricted focus on a mid-term horizon was deemed to be the most acceptable compromise between foresight and accuracy of predictions, despite that a long-term perspective would be more desirable. Finally, we used average values as entry parameters for simulation models in UJF and LJF farming systems. Overall, it is hoped that this study will inspire further research to help address some of these aspects.

8.3 Suggestions for further studies

Based on the findings of this study, the following suggestions for further research are proposed (answers to research question 6):

- Develop research focused on cost-effective methods that are applicable to small farmers to improve the fodder base, including improving agricultural production technology, storage, and harvesting that do not require large investments but offer reasonable environmental protection.
- Implement studies that elucidate circumstances that could promote income diversification strategies among farming systems focused on off-farm activities such as tourism or other value-added ventures.
- Implement studies on the typology of farming systems in other mountain regions such as Batken province (western Tien Shan) and Issyk-Kul (north-eastern Tien Shan) would provide additional insights into the socio-economic situation of farming systems in these regions. In addition, these regions are least studied so far.

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10. Appendices

> These questionnaire was designed to execute research for academic work. The main objective is to analyse the economic and social performance of the rural farm-households. All information will be used only and exclusively for academic purposes and all respondents will remain anonymous to the public”

List of appendices

Appendix 1: Questionnaire for analysis of farm economic and social performance

This questionnaire was integrated into the tablets using an open-source mobile application ODK (Open Data Kit).

1 Date: |____|

2 Interwiev Nr.: |____|

3 Village: |____|

4 Interwiever: |____|

5 Respondent: |____|

6 Respondent's status

CODE |____|

1 Household head; 2. Wife; 4 Son; 8. Other___

7 Respondent's education

CODE |____|

1. No education; 2. Incomplete secondary education (9-кл); 3. Secondary education;4. Agricultural college; 5. Non-agricultural college;6. Agricultural university; 7. Non-agricultural university

I. Utilization of walnut - fruit forest

What purposes do you use walnut-fruit forest for?

Mark if used for this purpose.

What is the most important? Please mark importance from 1 to 3

(1 - the most important)

Animal husbandry; Haymaking; Firewood; Collection of walnuts; Collection of wild apples; Collection of wild fruits and barriers; Collection of medicinal herbs; Collection of mushrooms;Tourism; Other|____|

Do you lease walnut-fruit forest plot? (Yes, No)

If yes: how many ha of forest plot do you lease? (ha) |____|

Do you pay for the lease by money or by something else?

If you pay with money how much do you pay annually? (KGS) |____|

If you pay with something else, what and how many do you give? |____|

How many years do you lease these forest plot for?

II. Collection and sale of forest products

What forest products do you collect and how much do you harvest?

Forest product Mark If you collect this product For marked forest products only: How often do you collect these forest products?

(every season, sometimes)

How many kg did you collect in 2020?

Did you sale these forest product?

(Yes, No)

If you sale, how many %? If you use only for HH how many % ?

1 Walnut; 2 Wild apples; 3 Mushrooms; (which species of mushroom, pls. give the name of mushroom |____|; 4 Wild fruits and barriers |____|; other |____|; other |____|; Hawthorn (Crataegus turkestanica);

Hawthorn (Crataegus pontica); Blackberry |____|; Raspberries|____|;Barberry|____|; Wild plum |____|;Wild cherry|____|; Wild pear|____|; Rosehip |____|; Wild currant |____|; Sea buckthorn|____|; Other |____|

5 Medicinal herbs

(what species of medicinal herbs?)

6 Other forest products

If you sale, to whom, where and what is the price of the sale?

Forest product

If sold, whom do you sale?

Where do you sale Price (som/kg 2020 жылда

Walnut|____| Wild apple

Hawthorn (*Crataegus knorringiana*)

Hawthorn (*Crataegus pontica*)

Wild plum |____|; Wild apple|____|; Rosehip |____|; Blackberry|____|; Raspberries|____|; Barberry |____|; Mushroom|____|; Seabackthorn|____|; Wild current Жапайи карагат|____|;Medicinal herbs |____|; Other|____|

How many persons and how much time is needed for collection?

Name kg Number of persons hours days

walnut|____|; wild apples|____|; Mushrooms|____|; Medicinal herbs|____|; Wild fruits|____|; other|____|

Do you hire another persons for collection? (Yes, No)

If yes: For how many days/hours? How much do you pay ?

Name Number of persons Days/hours Payment, soms If you pay with something, what do you pay with and how many?

Walnut|____|; Wild apples|____|;Mushrooms|____|; Medicinal herbs|____|; Wild fruits (write the name) |____|;

other|____|.

How do you transported the forest products and how far, what costs? (what is the distance from forest to the house, in km)?

....

Do you have sustainable sale channels? Do you need to search for whom to sale every year? How do you agree regarding the price? ....

III**. Processing**

Do you process collected forest products? (e.g jam, compote, dry fruits, juice)? (Yes, No)

If yes what forest products and in how do you process (dry fruits, jams, etc)

Final product:

a)dry fruits

b)jam; c)compote; d)juice; e)other (pls. write) :|____|

Walnut Wild apples Mushrooms Fruits and barriers (write which one) Medicinal herbs Other

What home equipment do you have for processing of forest product??

Mark if you have equipment

Dryer Juicer Meat grinder

Other equipment (pls. write) :|____|

Do you sale processed forest products ? (Yes, No – used for HH)

If sold:

How many persons and how much time needed for processing?

Name hours Number of persons

1.............; 2.............

If sold:

On what price, where and whom do you sale?

Name Whom do you sale? Where do you sale (city or village name)

Price (som/kg)

1.............

2.............

When do you sale processed forest products?

Name Jan Feb March Apr May June July Aug Sept Oct Nov Dec

1.............

2.............

Do you have sustainable sale channels? Do you need to search for whom to sale every year? How do you agree regarding the price? ....-

IV. **Changes in forest products**

What is your opinion: how the condition of forest have been changed for the last 10 years?

a)degraded; б)getting better ; в) remained the same г) I don’t know

If the answer is degraded or getting better: what are the reasons for such condition in your opinion?

How the amount of walnut have been changed for the last 10 years in your opinion?

a)decreased, б)increased , в)the same, г) I don’t know

If the response is the decreased, explain why do you think so?

How the amount of wild apples have been changed for the last 10 years in your opinion?

a)decreased, б)increased , в)the same, г) I don’t know

If the response is the decreased, explain why do you think so?

How the amount of other wild fruits have been changed for the last 10 years in your opinion?

a) decreased, б)increased , в)the same, г) I don’t know

If the response is the decreased, explain why do you think so?

I **Family (labour)**

8 How many people are in your family?

Number:|____|

8.1 Number of men in your family (LF)

0 - 10 |0,3| Number:|____|

11 - 16 |0,5| Number:|____|

17 and more |1,0| Number:|____|

8.2 Number of women in your family

0 - 10 |0,3| Number:|____|

11 - 16 |0,5| Number:|____|

17 and more |1,0| Number:|____|

9 How many family members has non-agricultural income sources? Amount:|____| (if 0 next question)

Number KGS/year

9.1 In village 1. Self employed |____| |_____|

2. Hired worker |____| |_____|

4. State employee |____| |_____|

8. Pensioner |____| |_____|

10 How many family members works out of village? If yes, what is the amount of annual remittances?

(if 0 next question)

Number KGS/year

|____| |_____|

11 How many family members works abroad? If yes, what is the amount of annual remittances? Number:|____|

(if 0 next question)

number KGS/year

1.____________ |____|

|_____| (должно добавляться)

12 Could you please indicate the dependence of non-agricultural income sources? CODE |___| (если 10=0, следующий вопрос)

1. Very (67%-100%) 2. In the middle (33%-66%)

3. Not much (0%-32%)

II **Land (asset)**

13 How many ha of arable land did you cultivate last year? ha |___| (if 0, go to question 18)

14 Indicate type agricultural land

CODE |___|

1. Arable land ha|___| 2. Rainfed ha|___|

8. Fallow ha|___|

15 How many ha of them are your own?

ha|___|

16 What type of crops did you cultivate? (comment)

17 What is the size of your kitchen garden?

ha|___|

(if 0 next chapter)

18 What did you cultivate on your kitchen garden? (comment)

19 How much do you earn from your kitchen garden?

KGS/year|___|

III **Mechanisation (assets)**

20 Do you have agricultural equipment? 1.Yes 2. No (if no, go to question 23)

21 If yes: What kind? (comment)

22 Do you provide contractors' services with your machinery? 1 – yes 2 – no CODE |____|

If yes How much do you earn?

KGS/year|____|

23 Do you have any mechanization challenges with in your villages?

1. Old equipment 2. Deficit of equipment 4. Services are expensive 8. Spares are expensive

....

IV **Animal husbandry** (assets, production system)

What kind of animals do you have?

1 Cattle 2 Horses 3 Sheep 4 Goats 5 Poultry

6 None

Animals

24 How many do you have? ....

. Number |___| (цифра)

24.1> 1 year |___|

24.21 – 2 year |___|

24.3 cow |___|

24.4 bull |___|

25 How much milk do you receive per cow/day?

L: |____|

26 How many months does cow lactate? Month |____|

27 Mortality rate of calves? Number |____|

28 How many months do you feed calf with milk? Month |____|

29 How many years do you use a cow? Year |____|

30 Do you have fattened-up animals? 1 – yes 2 – no CODE |____|

If yes

31 How many cattle? Number |___|

31.1How long? Month |___|

32 Did you sell a cow last year? 1.Yes 2. No (if No,go to question 33)

If yes: How many cattle and for how much? (comment)

Where did you sell animals?

1.On farm 2. Local market 3. Other

How much did you pay per cow to get to market? KGS/cow |___|

33 Did you process milk and sell it? 1.Yes 2. No (if no, go to question 35)

34 If yes: What do you process, how much and the price? (comment)

35 Do you use services of herders? 1 Yes, 2 No (if no, next q.) CODE|___|

If yes:

How many month/year? Month |____|

How much do you pay per animal/month?

KGS/animal |____|

Other payments (comment)

36 Did you animals suffer from any diseases? 1. Yes 2.No (if no, q. 40)

37 If yes: Which? (comment)

38 How many cattle do you kill for your own consumtion? animal|______| (if 0, next chapter)

Horse, sheep, goats similar to cattle

Poultry

39 Do you have poultry? 1) Yes 2) No (if yes, next q.)

If yes Number|____|

40 How many month does last grazing period of cattle?

Month |_____|

On remote pastures? Month |_____|

On middle pastures? Month |____|

Near the settlements (forest)? Month |____|

Kept indoor Month |____|

41 How many month does last grazing perod of horses?

Month |____|

On remote pastures? Month |____|

On middle pastures? Month |____|

Near the settlements (forest)? Month |____|

Kept indoor Month |____|

42 How much money do you spend for mdical treatment? KGS/year|_____|

43 Do you purchase additional fodder? 1 – Yes 2 – No CODE|___|

If yes

44 How much?

Hay Bundle, vehicle|____| KGS/ Bundle, vehicle |____|; Concentrates kg |____| KGS/kg |_____|45 What do you produce additionally? (comment)

46 Do you bees? 1 – Yes 2 – No CODE |___|

(if no, then next chapter)

47 How much honey do you collect month/year? kg |_____|

48 How much do you sell? kg |_____|

49 What is the price? KGS/kg |_____|

50 Where do you sell it? CODE |_____|

1. Village 2. Intermediate 4. Market

51 List the expenses of beekeeping (comment):

52 What challenges do you face in marketing your products (comment)?

....

....

....

Open questions:

53 Could you indicate impact of animal husbandry (grazing of animals) on wild apple trees? Could you tell if condition of wild apple trees gets worse in last years?

....

....

....

54 What kind of changes did happen in agricultural production system on your farm and overall- in the villages during recent decades?

....

....

....

55 How well-developed tourism and processing of forest fruits (wild apples) and agricultural products on your farm (village)?

....

....

....

56 What kind of plan/strategy do you have to improve your production methods (incl. Collecting wild apples and other NTFP, advanced processing of them, tourism)?

....

....

....

57 Has the Covid-19 affected to your activities (income sources, tourism, agricultural processes, etc.)?

....

....

In addition to this questionnaire, there is a second part of the questionnaire on livestock and crop production properties which was administered to more dedicated respondents. This part as well as questionnaire administered to agropastoral farm-households can be obtained upon request from the author.

Appendix 2 Ethical approval for conducting survey

UNIVERSITY
OF CENTRAL ASIA

14 June 2021

Dear Azamat,

I am writing to you on behalf of the University of Central Asia's Ethics Research Committee (UCA ERC) in response to your submission of an application for ethical approval for your study 'Conservation and Research of Wild Fruit Species in Western Tian Shan, Kyrgyz Republic'.

Having considered the information that you have provided, UCA ERC concluded that your proposal meets the requirements placed upon the ethical approval for the project. However, in light of COVID-19 crisis, the full ethical approval is granted with the proviso that the safety of both participants and researchers is of paramount importance and with considerations to limit the spread of COVID-19 in our communities.

It is also critical that you follow all guidelines issued by national health authorities and governments to ensure the compliance with all local requirements.

The standard conditions of the approval are:

- Approval is given for the entire period of study;
- Research should be conducted strictly in accordance with the submitted proposal and granted ethics approval;
- Approval is given on condition that any alterations proposed to the approved protocol are to be submitted to UCA ERC for approval prior to the alterations being made;
- Any issues in relation to the project that may warrant review of the ethical approval of the project need to be reported to UCA ERC;
- Research can be audited by UCA ERC during the research period to ensure compliance with the guidelines.

Please note that failure to comply with the conditions of approval and *UCA ERC Guidelines* may result in a withdrawal of approval for the project.

You may now commence your project. We wish you all the best in your endeavour.

Yours Sincerely,

Salim Sumar
Chair, Ethics Research Committee

Central Administration Office
138 Toktogul Street, Bishkek, 720001, Kyrgyz Republic
Telephone: +996 (312) 910 822, Fax: +996 (312) 910 835

Campuses in: Naryn, Kyrgyz Republic • Khorog Tajikistan • Tekeli, Kazakhstan **www.ucentralasia.org**

Appendix 3 Expert estimates of market price and factor costs and their accuracies

Table A 1 Comparison of expert estimates of market price and factor costs with their practical occurrence over time

Product	Average market price in December 2013, KGS	Average market price in December 2014, KGS	Average market price in December 2015, KGS	Average market price in December 2016, KGS	Expert estimates of average market price in December 2018, KGS			Average 2016 as % of most likely	Average 2016 within range min-max
					min	most likely	max		
Potatoes (KGS/kg)	20	29	16.4	23	20	24	25.4	96%	TRUE
Barley (KGS/kg)	8	11.6	13	8.1	6.5	7.76	8.5	104%	TRUE
Sugar beet (KGS/kg)	3	n/a	3.3	3.5	3	3.3	4.23	106%	TRUE
Vegetables from kitchen garden (KGS/kg)	18	28	21	19	22	27	27.4	70%	FALSE
Beef (KGS/kg)	299	352	324	297	296	320	347	93%	TRUE
Mutton (KGS/kg)	282	327	295	280	293	310	341	91%	TRUE
Horsemeat (KGS/kg)	290	330	314	292	264	301	311	94%	TRUE
Milk (KGS/kg)	35	40.8	36.7	36.7	36.4	38.5	46.5	95%	TRUE
Processed milk (cream) (KGS/kg)	199	223	213	220	229	248	278	88%	FALSE
Diesel (KGS/l)	40	42.5	37.4	32.7	38.8	41.6	47.2	79%	FALSE
Saltpeter (KGS/kg)	24	n/a	22	23	18	25	30	92%	TRUE
Wage labour, (KGS/month)	6,210	8,470	8,682	9,863	6,955	7,247	11,178	136%	TRUE
Interest rate, %	23	n/a	n/a	38	33	37.5	38	101%	TRUE

Average exchange rate in December 2016, 1.00 USD = 68.8 Kyrgyz som (KGS) (www.oanda.com).

Source: National Statistical Committee and Ministry of Economy of the Kyrgyz Republic (2014-2016), expert interviews

Appendix 4 Calculation of fodder energy content

Table A 2 Digestibility and feeding value of available feedstuff

OS[1]=	949	g		1.18	85%
Sainfoin hay					
	Gross energy	g	Factor		GE[2](MJ/kg)
In 1 kg DM:					
Crude protein		165.20	0.0239	=	3.95
Crude fat		29.50	0.0398	=	1.17
Crude fiber		265.5	0.0201	=	5.34
NfE[3]		518.02	0.0175	=	9.07
				MJ/kg (GE)	**19.52**
In 1 kg DM:		g	Factor		
Digestible crude fat		16.23	0.0312	=	0.51
Digestible crude fiber		132.75	0.0136	=	1.81
Digestible OS** (crude fat & fiber)		562.78	0.0147	=	8.27
Crude protein		165.20	0.00234	=	0.39
				MJ/kg(ME)	**10.97**
Calculation of the conversion efficiency					
q	(MJ/kg (GE)/MJ/kg (ME))*100				**56.19**
NEL	=	0,6*(1+0,004*(B19-57))*G16		**MJ NEL/kg**	**6.56**

OS*=	923	g		1.18	85%
Meadow hay					
		g	Factor		GE (MJ/kg)
In 1 kg DM:					
Crude protein		129.41176	0.0239	=	3.09
Crude fat		32.941176	0.0398	=	1.31
Crude fiber		263.52941	0.0201	=	5.30
NfE		518.82353	0.0175	=	9.08
				MJ/kg (GE)	**18.78**
In 1 kg DM:		g	Factor		
Digestible crude fat		16.470588	0.0312	=	0.51
Digestible crude fiber		150.2	0.0136	=	2.04
Digestible OS** (crude fat & fiber)		507.11	0.0147	=	7.45
Crude protein		129.41176	0.00234	=	0.30
				MJ/kg(ME)	**10.31**
Calculation of the conversion efficiency					
q	(MJ/kg (GE)/MJ/kg (ME))*100				**54.92**
NEL	=			**MJ NEL/kg**	**6.14**

Horse (Sainfoin)					
	g	Factor			
-3.54					
Crude protein	165.20	0.029	=	4.7908	
Crude fat	29.50	0.042	=	1.239	
Crude fiber	265.50	0.0001	=	0.02655	
NfE	518.02	0.0185	=	9.58337	
			MJ/kg (DE)	**12.09972**	

Horse (meadow hay)					
	g	Factor			
-3.54					
Crude protein	129.41	0.029	=	3.7529412	
Crude fat	32.94	0.042	=	1.3835294	
Crude fiber	263.53	0.0001	=	0.0263529	
NfE	518.82	0.0185	=	9.5982353	
				11.221059	**MJ/kg (DE)**

[1]Organic substance; [2]Gross energy; [3]N-free extract substances (NfE in German) are only recorded calculatively in feed analysis; [4]MJ Megajoule; [5]NEL net energy content for lactation (for dairy cows); [6]ME metabolizable energy (for ruminant animals); [7]DE digestible energy (for horses).

Table A 2 (continued)

OS*= 930 g			1.20	83%	**DM**	OS*= 972 g			1.204819	0.83
Barley straw						**Barley**				
	g	Factor					g	Factor		
In 1 kg DM:						**In 1 kg DM:**				
Crude protein	51.81	0.02	=	1.24		Crude protein	148.2	0.024	=	3.54
Crude fat	25.30	0.04	=	1.01		Crude fat	20.5	0.040	=	0.82
Crude fiber	422.89	0.02	=	8.50		Crude fiber	69.9	0.020	=	1.40
NfE	400.00	0.02	=	7.00		NfE	802.4	0.018	=	14.04
			MJ/kg(GE)	**17.75**	**MJ/kg (GE)**				**MJ/kg (GE)**	**19.80**
In 1 kg DM:	g	Factor				**In 1 kg DM:**	g	Factor		
Digestible crude fat	8.86	0.03	=	0.28		Digestible crude fat	12.90	0.031	=	0.40
Digestible crude fiber	228.36	0.01	=	3.11		Digestible crude fiber	4.19	0.014	=	0.06
Digestible OS** (crude fat & fiber)	237.08	0.01	=	3.49		Digestible OS** (crude fat & fiber)	877.14	0.015	=	12.89
Crude protein	51.81	0.00	=	0.12		Crude protein	148.19	0.002	=	0.35
			MJ/kg(ME)	**6.99**	**MJ/kg(ME)**				**MJ/kg(ME)**	**13.70**
Calculation of the conversion efficiency						**Calculation of the conversion efficiency**				
q	(MJ/kg (GE)/MJ/kg (ME))*100			**39.38**		q	(MJ/kg (GE)/MJ/kg (ME))*100			**69.18**
NEL			**MJNEL/kg**	**3.90**	**MJNEL/kg**	**NEL**			**MJNEL/kg**	**8.62**

Horses (barley straw)							**Horses (barley grain)**						
		g	Factor						g	Factor			
	- 3.54							-3.54					
Crude protein		51.81	0.03	=	1.50		Crude protein		148.19	0.03	=	4.2976	
Crude fat		25.30	0.04	=	1.06		Crude fat		20.48	0.04	=	0.8602	
Crude fiber		422.89	0.00	=	0.04		Crude fiber		69.88	0.00	=	0.007	
NfE		400.00	0.02	=	7.40		NfE		802.41	0.02	=	14.845	
					6.47	**MJ/kg(DE)**						**16.469**	**MJ/kg(DE)**

[1]Organic substance; [2]Gross energy; [3]N-free extract substances (NfE in German) are only recorded calculatively in feed analysis; [4]MJ Megajoule; [5]NEL net energy content for lactation (for dairy cows); [6]ME metabolizable energy (for ruminant animals); [7]DE digestible energy (for horses).

Appendix 5 Test of significant differnces of selected variables by analysis of variance (oneway) and t-test

Table A 3 Tests of homogeneity of variances

One-way		Levene Statistic	df1	df2	Sig.
Herd size	Based on Mean	9.045	2	217.00	0.00
	Based on Median	8.023	2	217.00	0.00
	Based on Median and with adjusted df	8.023	2	204.63	0.00
	Based on trimmed mean	8.811	2	217.00	0.00
Off-farm income	Based on Mean	6.015	2	217.00	0.00
	Based on Median	5.275	2	217.00	0.01
	Based on Median and with adjusted df	5.275	2	206.94	0.01
	Based on trimmed mean	5.995	2	217.00	0.00
Walnut revenues	Based on Mean	38.486	2	217.00	0.00
	Based on Median	30.988	2	217.00	0.00
	Based on Median and with adjusted df	30.988	2	140.77	0.00
	Based on trimmed mean	36.139	2	217.00	0.00
Other NTFP revenues	Based on Mean	1.702	2	217.00	0.18
	Based on Median	0.644	2	217.00	0.53
	Based on Median and with adjusted df	0.644	2	166.24	0.53
	Based on trimmed mean	0.977	2	217.00	0.38

Table A 4 One-way ANOVA test results

ANOVA		Sum of Squares	df	Mean Square	F	Sig.
Herd size	Between Groups	2118	2.0	1059	123.542	0.000
	Within Groups	1860	217.0	9		
	Total	3978	219.0			
Off-farm income	Between Groups	633606381356	2.0	316803190678	22.385	0.000
	Within Groups	3071154265735	217.0	14152784635		
	Total	3704760647091	219.0			
Walnut revenues	Between Groups	4728535319481	2.0	2364267659740	135.408	0.000
	Within Groups	3788892889610	217.0	17460335897		
	Total	8517428209091	219.0			
Other NTFP revenues	Between Groups	4398983937	2.0	2199491969	6.909	0.001
	Within Groups	69084542008	217.0	318361945		
	Total	73483525945	219.0			

Table A 5 Post hoc tests

Multiple Comparisons							
Tukey HSD (honestly significant difference)							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Herd size	**1**	2	-8.2036*	0.54	0.00	-9.47	-6.94
		3	-0.85082	0.44	0.14	-1.90	0.19
	2	1	8.2036*	0.54	0.00	6.94	9.47
		3	7.3528*	0.56	0.00	6.03	8.68
	3	1	0.850817	0.44	0.14	-0.19	1.90
		2	-7.3528*	0.56	0.00	-8.68	-6.03
Off-farm income	**1**	2	-94584.300*	21842.56	0.00	-146130.77	-43037.83
		3	57993.622*	17998.03	0.00	15519.91	100467.33
	2	1	94584.300*	21842.56	0.00	43037.83	146130.77
		3	152577.922*	22820.46	0.00	98723.71	206432.14
	3	1	-57993.622*	17998.03	0.00	-100467.33	-15519.91
		2	-152577.922*	22820.46	0.00	-206432.14	-98723.71
Walnut revenues	**1**	2	-121857.143*	24261.02	0.00	-179110.94	-64603.35
		3	-328493.506*	19990.80	0.00	-375669.99	-281317.03
	2	1	121857.143*	24261.02	0.00	64603.35	179110.94
		3	-206636.364*	25347.19	0.00	-266453.42	-146819.31
	3	1	328493.506*	19990.80	0.00	281317.03	375669.99
		2	206636.364*	25347.19	0.00	146819.31	266453.42
Other NTFP revenues	**1**	2	-4612.12	3276.00	0.34	-12343.17	3118.93
		3	-10031.2558*	2699.38	0.00	-16401.55	-3660.96
	2	1	4612.122	3276.00	0.34	-3118.93	12343.17
		3	-5419.13	3422.66	0.26	-13496.31	2658.04
	3	1	10031.2558*	2699.38	0.00	3660.96	16401.55
		2	5419.134	3422.66	0.26	-2658.04	13496.31

*The mean difference is significant at the 0.05 level.

Table A 6 Homogeneous subsets for variable 'herd size'

Herd size, LU			
Tukey HSD[a,b] Cluster Number of Case	N	Subset foralpha = 0.05	
		1	2
1	101	4.630	
3	77	5.481	
2	42		12.833
Sig.		0.228	1.00

Means for groups in homogeneous subsets are displayed.

[a] Uses Harmonic Mean Sample Size = 64.243.

[b] The group sizes are unequal.

The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table A 7 Homogeneous subsets for variable 'total off-farm income'

Off-farm income				
Tukey HSD[a,b] Cluster Number of Case	N	Subset for alpha = 0.05		
		1	2	3
3	77	120994		
1	101		178987	
2	42			273571
Sig.		1.00	1.00	1.00

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 64.243.

b. The group sizes are unequal. The harmonic mean of the group sizes is used.

Table A 8 Homogeneous subsets for variable 'Walnut revenues'

Total walnut revenues				
Tukey HSD[a,b] Cluster Number of Case	N	Subset for alpha = 0.05		
		1	2	3
1	101	40000		
2	42		161857.1	
3	77			368493.5
Sig.		1.00	1.00	1.00

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 64.243.

b. The group sizes are unequal. The harmonic mean of the group sizes is used

Table A 9 Homogeneous subsets for variable 'other NTFP revenues'

Other NTFP revenues			
Tukey HSD[a,b] Cluster Number of Case	N	Subset for alpha = 0.05	
		1	2
1	101	11169.31	
2	42	15781.43	15781.43
3	77		21200.56
Sig.		0.309	0.19

Means for groups in homogeneous subsets are displayed.

[a] Uses Harmonic Mean Sample Size = 64.243.

[b] The group sizes are unequal.

The harmonic mean of the group sizes is used. Type I error levels are not guaranteed

Table A 10 Group statistics (agropastoral farms-households)

(Z-Scores)					
Group Statistics					
Ward Method		N	Mean	Std. Deviation	Std. Error Mean
Elevation of village	1	104	-0.859	0.613	0.060
	2	129	0.693	0.654	0.058
Cultivated area	1	104	-0.195	0.369	0.036
	2	129	0.157	1.283	0.113
Pasturing period	1	104	0.415	0.591	0.058
	2	129	-0.335	1.131	0.100
Off-farm income	1	104	0.148	1.213	0.119
	2	129	-0.120	0.773	0.068

Table A 11 Independent samples test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Elevation of village	6.50	0.01	-18.53	231	0.00	-1.552	0.084	-1.717	-1.387
			-18.65	225.7	0.00	-1.552	0.083	-1.716	-1.388
Cultivated area	25.93	0.00	-2.706	231	0.00	-0.352	0.13	-0.608	-0.096
			-2.966	153.57	0.00	-0.352	0.119	-0.586	-0.117
Pasturing period	7.71	0.01	6.124	231	0.00	0.75	0.123	0.509	0.992
			6.512	200.7	0.00	0.75	0.115	0.523	0.977
Off-farm income	6.94	0.01	2.049	231	0.042	0.268	0.131	0.01	0.526
			1.958	167.0	0.052	0.268	0.137	-0.002	0.539

Appendix 6 Gross margin calculations of the cultivated crops and raised animals

Table A 12 Detailed gross margin calculation of the cultivated crops in UJF nd LJF farming systems

		n= 37			Wheat		JaiMi
Market performance		Variable	Share		Amount	KGS/Unit	KGS/ha
Yield t/ha					2.6		
Hauptleistung:	KGS/t	10.4			2527	10.4	26346
Nebenleistung I	KGS/t	5.2	3%		50	5.2	7
Nebenleistung II	KGS/bundle	46	74%		85.6	46	2921
Market performance total							**29274.8**
Proportional variable costs							
Seed					Amount	KGS/Unit	KGS/ha
Own seed					222	9.9	2196
Bght-seed	KGS/t	19.8			39	20	774
Total costs for seed							**2970**
Fertilization			Share		Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	26	5%		50.00	26.00	70
NPK Aquarin, Nutrivant	KGS/kg	167	8%		7.33	166.67	99
Manure	KGS/t	563	11%		4.00	562.50	243
Fertilization total							**413**
Plant protection					Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	1	38%		266	1	101
Herbicide	KGS/Unit	298	22%		2.03	298	131
Insecticide (PO China)		0.0					0
Insecticide (PO KARATE ZEON)							
Fungicide		338	11%		1.00	338	36
Pflanzenschutz gesamt							**268**
Services			Share	Amoun	Unit	KGS/Unit	KGS/ha
Ploughing							
Diesel	KGS/l	38.4		1.0	29.0	38.4	1114
Service of contrac	KGS/ha	854	100%	1.0		854	854
Harrowing							
Diesel				1.00	9.89	38.4	287
Service of contrac	KGS/ha	402	76%	1.00		402	304
Distributor (Fertilizer)							
Diesel				1.00	5.00	38.4	5
Service of contrac	KGS/ha	315	3%	1.00		315	8.51
Seeding							
Diesel				1.00	10.66	38.4	321
Service of contrac	KGS/ha	472	78%	1.00		472	370
Sprayer							
Diesel				1.43	6.86	38.4	71
Service of contrac	KGS/ha	364	19%	1.43		364	98
Harvester (PO/SB Digger)							
Diesel				1.00	34.51	38.4	1325
Service of contrac	KGS/ha	746	100%	1.00		746	746
Truck							
Benzin	KGS/l	31.4		1.36	6.48	31.4	172
Service of contrac	KGS/ha	446	62%	1.36		446	377
Mower (Hill up PO)							
Diesel						38.4	0
Service of contractor							0
Baler							
Service of contrac	KGS/ha	13.3	68%		85.6	13.30	769
Total costs for services							**6821**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	707.8					
Diesel		90%	640	38%	6.3	38.4	**241**
Benzin		90%	640	62%	12.7	31.4	**399**
Reparatur		10%	68.2		1.00	68.2	**68**
Total							**708**
Total proportional variable costs							**11180**
Amount of coverage							**18094.6**
Short term assets in average					50%	of var. cost	5590.1
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.96	5381	12%	646
Borrowed capital		19%		0.04	209	19%	40
Total costs for capital							**40**
Costs for labour							
			Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	34	48	87%	42	34	1412
Wage labour	KGS/m.h.	85	48	13%	6	85	536
							536
Costs for land					Share	KGS/ha	KGS
Own land	KGS/ha	3468			73%	3468	2535
Leased land	KGS/ha	3468			27%	3468	932
Total costs for land							**932**
Other production costs							**743**
Variable costs II total							**2252**
Total production costs KGS/ha(ohne AV, fix. Costs)							**13432**
Profit KGS/ha (without fix&inderect costs)							**15843**
Average Profit total KGS				0.46	1.3	0.34	**7220**

		n= 4			Wheat		JaiHi
Market performance		Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha					2.2		
Hauptleistung:	KGS/t	8.68			2025	8.7	17567
Nebenleistung I	KGS/t	4.3	25%		200	4.3	217
Nebenleistung II	KGS/bundle	39	100%		72.8	39	2821
Market performance total							**20604.8**
Proportional variable costs							
Seed			Share		Amount	KGS/Unit	KGS/ha
Own seed					188	8	1545
Bght-seed	KGS/t	22.0			63	22	1375
Total costs for seed							**2920**
Fertilization					Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	0	0%		0.00	0.00	0
NPK Aquarin, Nutrivant	KGS/kg	0	0%		0.00	0.00	0
Manure	KGS/t	0	0%		0.00	0.00	0
Fertilization total							
Plant protection					Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	1	100%		250	1	250
Herbicide	KGS/Unit	0	0%			0	0
Insecticide (PO China)		0				0	0
Insecticide (PO KARATE ZEON)							
Fungicide		0				0	0
Pflanzenschutz gesamt							**250**
Services				Amoun	Unit	KGS/Unit	KGS/ha
Ploughing							
Diesel	KGS/l	39.5		1.0	28.3	39.5	1119
Service of contrac	KGS/ha	755	100%	1.0		755	755
Harrowing							
Diesel				1.00	10.00	39.5	198
Service of contrac	KGS/ha	280	50%	1.00		280	140
Distributor (Fertilizer)							
Diesel						39.5	0
Service of contrac	KGS/ha		0%			0	0
Seeding							
Diesel				1.00	9.67	39.5	286
Service of contrac	KGS/ha	353	75%	1.00		353	265
Sprayer							
Diesel						39.5	0
Service of contrac	KGS/ha		0%			0	0
Harvester (PO/SB Digger)							
Diesel				1.00	37.50	39.5	1481
Service of contrac	KGS/ha	743	100%	1.00		743	743
Truck							
Benzin	KGS/l	31.0		1.00	6.00	31.0	186
Service of contrac	KGS/ha	564	100%	1.00		564	564
Mower (Hill up PO)							
Diesel						39.5	0
Service of contractor							0
Baler							
Service of contrac	KGS/ha	10.5	100%		72.8	10.54	767
Total costs for services							**6504**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	1182.8					
Diesel		89%	1048	40%	10.5	39.5	**417**
Benzin		89%	1048	60%	20.4	31.0	**632**
Reparatur		11%	134.3		1.00	134.3	**134**
Total							**1183**
Total proportional variable costs							**10857**
Amount of coverage							**9747.56**
Short term assets in average					50%	of var. cost	5428.6
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		1.00	5429	12%	651
Borrowed capital		19%		0.00	0	19%	0
Total costs for capital							**0**
Costs for labour							
			Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	34	46	81%	38	34	1280
Wage labour	KGS/m.h.	85	46	19%	9	85	731
							731
Costs for land					Share	KGS/ha	KGS
Own land	KGS/ha	1900			63%	1900	1202
Leased land	KGS/ha	1900			37%	1900	698
Total costs for land							**698**
Other production costs							**735**
Variable costs II total							**2164**
Total production costs KGS/ha(ohne AV, fix. Costs)							**13021**
Profit KGS/ha (without fix&inderect costs)							**7584**
Average Profit total KGS				0.07	2.3	0.03	**546**

		n= 75			Barley		JaiMi
Market performance		Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha					2.4		
Hauptleistung:	KGS/t	8.78			2389	8.8	20984
Nebenleistung I	KGS/t						
Nebenleistung II	KGS/bundle	45	71%		87.6	45	2786
Market performance total							**23770.5**
Proportional variable costs							
Seed					Amount	KGS/Unit	KGS/ha
Own seed					196	8.3	1637
Bght-seed	KGS/t	16.3			58	16	943
Total costs for seed							**2580**
Fertilization					Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	31	4%		108	31.00	134
NPK Aquarin, Nutrivant	KGS/kg	150	1%		1.67	150.00	3.33
Manure	KGS/t	117	4%		9.67	116.67	45
Fertilization total							**183**
Plant protection					Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	1	23%		256	1	58
Herbicide	KGS/Unit	573	12%		1.36	573	93
Insecticide (PO China)		500	1%		1.00	500	6.7
Insecticide (PO KARATE ZEON)							
Fungicide		325	3%		1.00	325	9
Pflanzenschutz gesamt							**167**
Services				Amoun	Unit/ha	KGS/Unit	KGS/ha
Ploughing							
Diesel	KGS/l	38.5		1.0	31.1	38.5	1022
Service of contrac	KGS/ha	746	85%	1.0		746	636
Harrowing							
Diesel				1.00	9.64	38.5	297
Service of contrac	KGS/ha	433	80%	1.00		433	347
Distributor (Fertilizer)							
Diesel				1.00	5.00	38.5	5.14
Service of contrac	KGS/ha	308	3%	1.00		308	8.20
Seeding							
Diesel				1.00	10.58	38.5	326
Service of contrac	KGS/ha	497	80%	1.00		497	398
Sprayer							
Diesel				1.18	7.09	38.5	51.65
Service of contrac	KGS/ha	312	16%	1.18		312	58.98
Harvester (PO/SB Digger)							
Diesel				1.00	32.65	38.5	1240.86
Service of contrac	KGS/ha	842	99%			842	0.00
Truck							
Benzin	KGS/l	31.4		1.47	5.75	31.4	266
Service of contrac	KGS/ha	448	73%	1.47		448	0
Mower (Hill up PO)							
Diesel						38.5	0
Service of contractor							0
Baler							
Service of contrac	KGS/ha	18.4	65%		87.6	18.36	1051
Total costs for services							**5708**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	498.63					
Diesel		90%	451	38%	4.4	38.5	**170**
Benzin		90%	451	62%	8.9	31.4	**281**
Reparatur		10%	48.1		1.00	48.1	**48**
Total							**499**
Total proportional variable costs							**9135**
Amount of coverage							**14635.1**
Short term assets in average					50%	of var. cost	4567.7
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.92	4194	12%	503
Borrowed capital		22%		0.08	374	22%	82
Total costs for capital							**82**
Costs for labour							
			Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	34	48	87%	42	34	1412
Wage labour	KGS/m.h.	85	48	13%	6	85	536
							536
Costs for land					Share	KGS/ha	KGS
Own land	KGS/ha	3468			73%	3468	2535
Leased land	KGS/ha	3468			27%	3468	932
Total costs for land							**932**
Other production costs							**743**
Variable costs II total							**2293**
Total production costs KGS/ha(ohne AV, fix. Costs)							**11429**
Profit KGS/ha (without fix&inderect costs)							**12342**
Average Profit total KGS				1.03	1.5	0.69	**12765**

		n= 52			Barley		JaiHi
Market performance		Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha					2.2		
Hauptleistung:	KGS/t	9.2			2187	9.2	20049
Nebenleistung I	KGS/t						
Nebenleistung II	KGS/bundle	45	77%		87.4	45	3058
Market performance total							**23107.3**
Proportional variable costs							
Seed					Amount	KGS/Unit	KGS/ha
Own seed					139	9	1207
Bght-seed	KGS/t	14.4			106	14	1519
Total costs for seed							**2726**
Fertilization					Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	35	2%		100	35.00	67
NPK Aquarin, Nutrivant	KGS/kg	0	0%		0	0	0.00
Manure	KGS/t	200	2%		6.00	200.00	23
Fertilization total							**90**
Plant protection					Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	1	23%		211	1	49
Herbicide	KGS/Unit	115	4%		0.62	115	3
Insecticide (PO China)		0			0.00	0	0.0
Insecticide (PO KARATE ZEON)							
Fungicide		513	4%		1.50	513	30
Pflanzenschutz gesamt							**81**
Services				Amoun	Unit	KGS/Unit	KGS/ha
Ploughing							
Diesel	KGS/l	40.0		1.0	30.6	40.0	1037
Service of contrac	KGS/ha	537	85%	1.0		537	455
Harrowing							
Diesel				1.00	9.56	40.0	287
Service of contrac	KGS/ha	353	75%	1.00		353	265
Distributor (Fertilizer)							
Diesel				0.00	0.00	40.0	0.00
Service of contrac	KGS/ha	0	0%			0	0.00
Seeding							
Diesel				1.00	9.72	40.0	292
Service of contrac	KGS/ha	344	75%	1.00		344	258
Sprayer							
Diesel				0.00	0.00	40.0	0.00
Service of contrac	KGS/ha	0				0	0.00
Harvester (PO/SB Digger)							
Diesel				1.00	32.16	40.0	1262
Service of contrac	KGS/ha	936	98%	1.00		936	918
Truck							
Benzin	KGS/l	32.1		1.38	6.20	32.1	275
Service of contrac	KGS/ha	432	79%	1.38		432	0
Mower (Hill up PO)							
Diesel						40.0	0
Service of contractor							0
Baler							
Service of contrac	KGS/ha	12.5	75%		87.4	12.47	817
Total costs for services							**5866**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	736.17					
Diesel		89%	653	38%	6.1	40.0	**246**
Benzin		89%	653	62%	12.7	32.1	**407**
Reparatur		11%	83.6		1.00	83.6	**84**
Total							**736**
Total proportional variable costs							**9500**
Amount of coverage							**13607.4**
Short term assets in average					50%	of var. cost	4749.9
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.95	4490	12%	539
Borrowed capital		22%		0.05	260	22%	57
Total costs for capital							**57**
Costs for labour							
			Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	34	46	81%	38	34	1280
Wage labour	KGS/m.h.	85	46	19%	9	85	731
							731
Costs for land					Share	KGS/ha	KGS
Own land	KGS/ha	1900			63%	1900	1202
Leased land	KGS/ha	1900			37%	1900	698
Total costs for land							**698**
Other production costs							**735**
Variable costs II total							**2220**
Total production costs KGS/ha(ohne AV, fix. Costs)							**11720**
Profit KGS/ha (without fix&inderect costs)							**11387**
Average Profit total KGS				1.78	4.3	0.42	**20297**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 12 (continued).

		n= 58		Potatoes		JaiMi	
Market performance		Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha					*18.5*		
Hauptleistung:	KGS/t	11.76			12256	12	144118
Nebenleistung I	KGS/t	7			6201	7	43748
Nebenleistung II	KGS/bundle	1			368.2	1	433
Market performance total							**188299**
Proportional variable costs							
Seed					Amount	KGS/Unit	KGS/ha
Own seed					3323	11	35164
Bght-seed	KGS/t	13			210	13	2766
Total costs for seed							**37931**
Fertilization					Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	22	36%		219	22.14	1754
NPK Aquarin, Nutrivant	KGS/kg	195	2%		3.00	195.00	10
Manure	KGS/t	141	45%		6.69	141	423
Fertilization total							**2,187**
Plant protection					Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	0			0	0	0
Herbicide	KGS/Unit	1015	21%		1.37	1015	287
Insecticide (PO China)		5.5	22%		24.54	5.5	30
Insecticide (PO KARATE ZEON)		1577	22%		1.62	1577	571
Fungicide		1060	9%		2.10	1060	192
Pflanzenschutz gesamt							**1080**
Services				Amoun	Unit/ha	KGS/Unit	KGS/ha
Ploughing							
Diesel	KGS/l	38.4		1.00	30.7	38.4	1015
Service of contrac	KGS/ha	712	86%	1.00		712	614
Harrowing							
Diesel				1.00	9.0	38.4	191
Service of contrac	KGS/ha	386	55%	1.00		386	213
Distributor (Fertilizer)							
Diesel				1.00	5.00	38.4	7
Service of contrac	KGS/ha	313	3%	1.00		313	11
Seeding							
Diesel				1.00	29.26	38.4	658
Service of contrac	KGS/ha	984	59%	1.00		984	577
Sprayer							
Diesel				1.50	8.80	38.4	87
Service of contrac	KGS/ha	326	17%	1.50		326	84
Harvester (PO/SB Digger)							
Diesel				1.00	44.02	38.4	1253
Service of contrac	KGS/ha	2378	74%	1.00		2378	1763
Truck							
Benzin	KGS/l	31		3.23	6.25	31.4	306
Service of contrac	KGS/ha	310	48%	3.23		310	484
Mower (Hill up PO)							
Diesel				2.53	11.194	38.4	599
Service of contractor		396	55%	2.53		396	552
Baler							
Service of contrac	KGS/ha						
Total costs for services							**8416**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	1127.8					
Diesel		96%	1079	43%	12.2	38.4	**469**
Benzin		96%	1079	57%	19.4	31.4	**610**
Reparatur		4%	48.8		1.00	48.8	**49**
Total							**1128**
Total proportional variable costs							**50741**
Amount of coverage							**137558**
Short term assets in average					50%	of var. cost	25371
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.92	23220	12%	2786
Borrowed capital		22%		0.08	2151	22%	469
Total costs for capital							**469**
Costs for labour							
			Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	34	414	62%	259	34	8798
Wage labour	KGS/m.h.	85	414	38%	155	85	13209
							13209
Costs for land					Share	KGS/ha	KGS
Own land	KGS/ha	4610			76%	4610	3518
Leased land	KGS/ha	4610			24%	4610	1092
Total costs for land							**1092**
Other production costs							**2067**
Variable costs II total							**16836**
Total production costs KGS/ha(ohne AV fix. Costs)							**67577**
Profit KGS/ha (without fix&inderect costs)							**120722**
Average Profit total KGS				0.38	0.7	0.54	**46456**

		n= 47		Potatoes		JaiHi	
Market performance		Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha					*22.4*		
Hauptleistung:	KGS/t	10			13531	10	137903
Nebenleistung I	KGS/t	6			8825	6	53962
Nebenleistung II	KGS/bundle	1			95.7	1	98
Market performance total							**191963**
Proportional variable costs							
Seed					Amount	KGS/Unit	KGS/ha
Own seed					2765	9	25359.37
Bght-seed	KGS/t	21			107	21	2279
Total costs for seed							**27639**
Fertilization					Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	28	4%		85	28.00	101
NPK Aquarin, Nutrivant	KGS/kg	0			0	0.00	0
Manure	KGS/t	141	94%		7.81	141	1029
Fertilization total							**1,130**
Plant protection					Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	0.0			0	0	0
Herbicide	KGS/Unit	827	26%		1.00	827	211
Insecticide (PO China)		0.0	0%		0.00	0	0
Insecticide (PO KARATE ZEON)		0	0%		0.00	0	0
Fungicide		0	0%		0.00	0	0
Pflanzenschutz gesamt							**211**
Services				Amoun	Unit	KGS/Unit	KGS/ha
Ploughing							
Diesel	KGS/l	40.4		1.00	31.2	40.4	672
Service of contrac	KGS/ha	917	53%	1.00		917	488
Harrowing							
Diesel				1.00	8.7	40.4	127
Service of contrac	KGS/ha	438	36%	1.00		438	159
Distributor (Fertilizer)							
Diesel				0.00	0.00	40.4	0
Service of contrac	KGS/ha	0	0%	0.00		0	0
Seeding							
Diesel				1.00	35.00	40.4	60
Service of contrac	KGS/ha	983	4%	1.00		983	42
Sprayer							
Diesel				0.00	0.00	40.4	0
Service of contrac	KGS/ha	0	0%	0.00		0	0
Harvester (PO/SB Digger)							
Diesel				1.00	37.50	40.4	194
Service of contrac	KGS/ha	1055	13%	1.00		1055	135
Truck							
Benzin	KGS/l	32		2.67	5.00	32.0	73
Service of contrac	KGS/ha	340	17%	2.67		340	154
Mower (Hill up PO)							
Diesel				1.5	16.5	40.4	149
Service of contractor		467	15%	1.5		466.86	104
Baler							
Service of contrac	KGS/ha						
Total costs for services							**2357**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	36					
Diesel		96%	35	43%	0.4	40.4	**15**
Benzin		96%	35	57%	0.6	32.0	**20**
Reparatur		4%	1.6		1.00	1.6	**2**
Total							**36**
Total proportional variable costs							**31372**
Amount of coverage							**160591**
Short term assets in average					50%	of var. cost	15686.2
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		92%	14356	12%	1723
Borrowed capital		21%		8%	1330	21%	275
Total costs for capital							**275**
Costs for labour							
			Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	34	414	90%	371	34	12626
Wage labour	KGS/m.h.	85	414	10%	43	85	3639
							3639
Costs for land					Share	KGS/ha	KGS
Own land	KGS/ha	2335			86%	2335	2010
Leased land	KGS/ha	2335			14%	2335	326
Total costs for land							**326**
Other production costs							**1929**
Variable costs II total							**6170**
Total production costs KGS/ha(ohne AV fix. Costs)							**37542**
Profit KGS/ha (without fix&inderect costs)							**154421**
Average Profit total KGS				0.10	0.27	0.38	**15627**

		n= 81		Alfalfa		JaiMi	
Market performance		Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha				*6.4*	*377.5*		
Hauptleistung:	KGS/t	146	bundle (17 kg)		377.5	146	55128
Nebenleistung I	KGS/t						0
Nebenleistung II	KGS/bundle						0
Market performance total							**55127.7**
Proportional variable costs							
Seed					Amount	KGS/Unit	KGS/ha
Own seed							
Bght-seed	KGS/t	450			5.00	450	2250
Total costs for seed							**2250**
Fertilization					Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	0.00				0.00	0
NPK Aquarin, Nutrivant	KGS/kg	0.00				0.00	0
Manure	KGS/t	0.00				0.00	0
Fertilization total							**0**
Plant protection					Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	0				0	0
Herbicide	KGS/Unit	0				0	0
Insecticide (PO China)		0				0	0
Insecticide (PO KARATE ZEON)		0				0	0
Fungicide		0				0	0
Pflanzenschutz gesamt							**0**
Services				Amoun	Unit/ha	KGS/Unit	KGS/ha
Ploughing							
Diesel	KGS/l	38.5		0.00	0.0	38.5	0
Service of contrac	KGS/ha	0	0%	0.00		0	0
Harrowing							
Diesel				1.00	8.0	38.5	15
Service of contrac	KGS/ha	344	5%	1.00		344	17
Distributor (Fertilizer)							
Diesel				0.00	0.00	38.5	0
Service of contrac	KGS/ha	0				0	0
Seeding							
Diesel				0.00	0.00	38.5	0
Service of contrac	KGS/ha	0				0	0
Sprayer							
Diesel				0.00	395.84	38.5	0
Service of contrac	KGS/ha	0				0	0
Harvester (PO/SB Digger)							
Diesel				0.00	0.00	38.5	0
Service of contrac	KGS/ha	0				0	0
Truck							
Benzin	KGS/l	31		2.52	5.76	31.3	298
Service of contrac	KGS/ha	350	66%	2.52	1.00	350	578
Mower (Hill up PO)							
Diesel				1.961	10	38.5	670
Service of contractor		1050	89%	1.961		1050	1829
Baler							
Service of contrac	KGS/ha	11.5	79%		377.5	11.49	3426
Total costs for services							**6835**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	678.31					
Diesel		96%	649	84%	14.2	38.5	**547**
Benzin		96%	649	16%	3.3	31.3	**102**
Reparatur		4%	28.9		1.00	28.9	**29**
Total							**678**
Total proportional variable costs							**9763**
Amount of coverage							**45364.9**
Short term assets in average					50%	of var. cost	4881.4
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.91	4458	12%	535
Borrowed capital		20%		0.09	423	20%	83
Total costs for capital							**83**
Costs for labour							
			Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	35	70	85%	60	35	2091
Wage labour	KGS/m.h.	87	70	15%	10	87	901
							901
Costs for land					Share	KGS/ha	KGS
Own land	KGS/ha	3906			75%	3906	2932
Leased land	KGS/ha	3906			25%	3906	974
Total costs for land							**974**
Other production costs							**748**
Variable costs II total							**2706**
Total production costs KGS/ha(ohne AV fix. Costs)							**12469**
Profit KGS/ha (without fix&inderect costs)							**42659**
Average Profit total KGS				1.44	1.9	0.75	**61279**

		n= 9		Alfalfa		JaiHi	
Market performance		Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha				*3.8*	*225.3*		
Hauptleistung:	KGS/t	147	bundle (17 kg)		225.3	147	33167
Nebenleistung I	KGS/t						0
Nebenleistung II	KGS/bundle						0
Market performance total							**33167.1**
Proportional variable costs							
Seed					Amount	KGS/Unit	KGS/ha
Own seed							
Bght-seed	KGS/t	450			5.00	450	2250
Total costs for seed							**2250**
Fertilization					Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	0.00				0.00	0
NPK Aquarin, Nutrivant	KGS/kg	0.00				0.00	0.0
Manure	KGS/t	0.00				0.00	0.0
Fertilization total							**0**
Plant protection					Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	0				0	0
Herbicide	KGS/Unit	0				0	0
Insecticide (PO China)		0				0	0
Insecticide (PO KARATE ZEON)		0				0	0
Fungicide		0				0	0
Pflanzenschutz gesamt							**0**
Services				Amoun	Unit	KGS/Unit	KGS/ha
Ploughing							
Diesel	KGS/l	40.2		0.00	0.0	40.2	0
Service of contrac	KGS/ha	0	0%	0.00		0	0
Harrowing							
Diesel				0.00	0.0	40.2	0
Service of contrac	KGS/ha	0			0.00	0	0
Distributor (Fertilizer)							
Diesel				0.00	0.00	40.2	0.00
Service of contrac	KGS/ha	0				0	0
Seeding							
Diesel				0.00	0.00	40.2	0
Service of contrac	KGS/ha	0				0	0
Sprayer							
Diesel				0.00	0.00	40.2	0
Service of contrac	KGS/ha	0				0	0
Harvester (PO/SB Digger)							
Diesel				0.00	0.00	40.2	0
Service of contrac	KGS/ha	0				0	0
Truck							
Benzin	KGS/l	32		1.50	6.25	31.8	19
Service of contrac	KGS/ha	302	6%	1.50		302	29
Mower (Hill up PO)							
Diesel				1.22	10	40.2	35
Service of contractor		920	7%	1.22		920	81
Baler							
Service of contrac	KGS/ha	9.8	56%		225.3	9.77	1222
Total costs for services							**1387**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	686.11					
Diesel		89%	614	91%	13.8	40.2	**556**
Benzin		89%	614	9%	1.8	31.8	**57**
Reparatur		11%	72.3		1.00	72.3	**72**
Total							**686**
Total proportional variable costs							**4323**
Amount of coverage							**28844.2**
Short term assets in average					50%	of var. cost	2161.4
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		92%	1993	12%	239
Borrowed capital		23%		8%	168	23%	39
Total costs for capital							**39**
Costs for labour							
			Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	37	62	89%	56	37	2056
Wage labour	KGS/m.h.	92	62	11%	7	92	610
							610
Costs for land					Share	KGS/ha	KGS
Own land	KGS/ha	3906			84%	3906	3286
Leased land	KGS/ha	3906			16%	3906	621
Total costs for land							**621**
Other production costs							**440**
Variable costs II total							**1709**
Total production costs KGS/ha(ohne AV fix. Costs)							**6031**
Profit KGS/ha (without fix&inderect costs)							**27136**
Average Profit total KGS				0.12	1.7	0.07	**3321**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 12 (continued).

		n= 17			Sainfoin		JaiMi	n=	54		Sainfoin		JaiHi	n= 47			Hay meadow		JaiMi	n= 70			Hay meadow		JaiHi
Market performance		Variables			Amount	KGS/Unit	KGS/ha	Variables			Amount	KGS/Unit	KGS/ha	Variables			Amount	KGS/Unit	KGS/ha	Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha				*4.1*	*241.9*					*3.3*	*196.1*					*2.7*	*156.2*					*1.9*	*111.3*		
Hauptleistung:	KGS/t	115	bundle (17 kg)		241.9	115	27745	125	bundle (17 kg)		196.1	125	24499	91	bundle (17 kg)		156.2	91	14284	116	bundle (17 kg)		111.3	116	12870
Nebenleistung I	KGS/t						0						0						0						0
Nebenleistung II	KGS/bundle						0						0						0						0
Market performance total							**27745.4**						**24498.9**						**14284.4**						**12869.9**
Proportional variable costs																									
Seed					Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha
Own seed					0.0	103	1				0.0	112	0.234401				0.0	82	0				0.0	104	0
Bght-seed	KGS/t	100			33.00	100	3300	100			33.00	100	3300	0			0.00	0	0	0			0.00	0	0
Total costs for seed							**3301**						**3300**						**0**						**0**
Fertilization					Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	0.00				0.00	0	0.00				0.00	0	0.00				0.00	0	0.00				0.00	0
NPK Aquarin, Nutrivant	KGS/kg	0.00				0.00	0	0.00				0.00	0.0	0.00				0.00	0	0.00				0.00	0.0
Manure	KGS/t	0.00				0.00	0	0.00				0.00	0.0	0.00				0.00	0	0.00				0.00	0.0
Fertilization total							**0**						**0**						**0**						**0**
Plant protection					Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg	0				0	0	0.0				0	0	0				0	0	0.0				0	0
Herbicide	KGS/Unit	0				0	0	0				0	0	0				0	0	0				0	0
Insecticide (PO China)		0.0				0	0	0.0				0	0	0.0				0	0	0.0				0	0
Insecticide (PO KARATE ZEON)		0				0	0	0				0	0	0				0	0	0				0	0
Fungicide		0				0	0	0				0	0	0				0	0	0				0	0
Pflanzenschutz gesamt							**0**						**0**						**0**						**0**
Services				Amoun	Unit/ha	KGS/Unit	KGS/ha			Amoun	Unit	KGS/Unit	KGS/ha			Amoun	Unit/ha	KGS/Unit	KGS/ha			Amoun	Unit	KGS/Unit	KGS/ha
Ploughing																									
Diesel	KGS/l	39.4		1.00	30.0	39.4	208	40.5		1.00	30.0	40.5	158	38.0		0.00	0.0	38.0	0	38.4		0.00	0.0	38.4	0
Service of contrac	KGS/ha	780	18%	1.00		780	138	903	13%	1.00		903	117	0			1.00	0	0	0			1.00	0	0
Harrowing																									
Diesel				1.00	10.0	39.4	93			1.00	10.0	40.5	53			0.00	0.0	38.0	0			0.00	0.0	38.4	0
Service of contrac	KGS/ha	300	24%	1.00		300	71	311	13%	1.00		311	40	0			1.00	0	0	0			1.00	0	0
Distributor (Fertilizer)																									
Diesel				0.00	0.00	39.4	0			0.00	0.00	40.5	0			0.00	0.00	38.0	0			0.00	0.00	38.4	0
Service of contrac	KGS/ha	0				0	0	0				0	0	0			1.00	0	0	0			1.00	0	0
Seeding																									
Diesel				1.00	10.00	39.4	69			1.00	10.00	40.5	38			0.00	0.00	38.0	0			0.00	0.00	38.4	0
Service of contrac	KGS/ha	403	18%	1.00		403	71	498	9%	1.00		498	46	0			1.00	0	0	0			1.00	0	0
Sprayer																									
Diesel				0.00	0.00	39.4	0			0.00	0.00	40.5	0			0.00	0.00	38.0	0			0.00	0.00	38.4	0
Service of contrac	KGS/ha	0				0	0	0				0	0	0			1.00	0	0	0			1.00	0	0
Harvester (PO/SB Digger)																									
Diesel				0.00	0.00	39.4	0			0.00	0.00	40.5	0			0.00	0.00	38.0	0			0.00	0.00	38.4	0
Service of contrac	KGS/ha	0				0	0	0				0	0	0			1.00	0	0	0			1.00	0	0
Truck																									
Benzin	KGS/l	32		1.61	5.33	31.6	204	32		1.31	6.07	32.0	254	31		1.04	5.00	31.3	104	32		0.72	5.31	32.3	108
Service of contrac	KGS/ha	325	75%	1.61		325	393	345	100%	1.31		345	452	410	64%	1.04		410	273	377	87%	0.72	1.00	377	238
Mower (Hill up PO)																									
Diesel				1.231	10	39.4	342			1.077	10	40.5	372			1	10	38.0	226			1	10	38.4	291
Service of contractor		1079	71%	1.231		1079.17	938	836	85%	1.077	1	836.46	767	893	60%	1		893	532	903	76%	1		902.54	683
Baler																									
Service of contrac	KGS/ha	13.2	71%		241.9	13.21	2255	12.1	81%		196.1	12.06	1927	11.0	30%		156.2	10.99	511	11.4	34%		111.3	11.36	433
Total costs for services							**4781**						**4223**						**1646**						**1754**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha	KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha	KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha	KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/h	661.79						1257.2						289.02						147.89					
Diesel		94%	625	88%	14.0	39.4	**552**	93%	1170	81%	23.3	40.5	**942**	88%	255	83%	6	38.0	**210**	92%	136	83%	2.9	38.4	**113**
Benzin		94%	625	12%	2.3	31.6	**74**	93%	1170	19%	7.1	32.0	**228**	88%	255	17%	1.4	31.3	**44**	92%	136	17%	0.7	32.3	**24**
Reparatur		6%	36.6		1.00	36.6	**37**	7%	87.3		1.00	87.3	**87**	12%	34.5		1.00	34.5	**34**	8%	11.6		1.00	11.6	**12**
Total							**662**						**1257**						**289**						**148**
Total proportional variable costs							**8743**						**8780**						**1935**						**1902**
Amount of coverage							**19002.2**						**15718.6**						**12349.8**						**10968.2**
Short term assets in average					50%	of var. cost	4371.6				50%	of var. cost	4390.2				50%	of var. cost	967.3				50%	of var. cost	950.9
Costs for capital for short term assets																									
				Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha
Own capital		12%		0.95	4168	12%	500	12%		0.88	3872	12%	465	12%		0.84	815	12%	98	12%		0.92	871	12%	104
Borrowed capital		26%		0.05	204	26%	53	21%		0.12	518	21%	110	22%		0.16	152	22%	34	24%		0.08	80	24%	19
Total costs for capital							**53**						**110**						**34**						**19**
Costs for labour																									
			Total m	Share	m.h./ha	KGS/h	KGS/ha		Total m	Share	m.h./ha	KGS/h	KGS/ha		Total m	Share	m.h./ha	KGS/h	KGS/ha		Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	34	56	81%	46	34	1549	34	65	91%	59	34	2033	37	59	82%	49	37	1811	34	42	91%	38	34	1304
Wage labour	KGS/m.h.	85	56	19%	11	85	913	86	65	9%	6	86	521	93	59	18%	11	93	979	85	42	9%	4	85	322
							913						**521**						**979**						**322**
Costs for land					Share	KGS/ha	KGS				Share	KGS/ha	KGS				Share	KGS/ha	KGS				Share	KGS/ha	KGS
Own land	KGS/ha	3264			84%	3264	2735	1832			82%	1832	1495	1520			77%	1520	1167	1047			87%	1047	913
Leased land	KGS/ha	3264			16%	3264	529	1832			18%	1832	337	1723			23%	1723	400	956			13%	956	122
Total costs for land							**529**						**337**						**400**						**122**
Other production costs							**494**						**504**						**370**						**276**
Variable costs II total							**1989**						**1471**						**1783**						**740**
Total production costs KGS/ha(ohne AV		**fix. Costs)**					**10732**						**10252**						**3717**						**2642**
Profit KGS/ha (without fix&inderect costs)							**17013**						**14247**						**10567**						**10228**
Average Profit total KGS				0.28	1.8	0.16	**4750**			1.57	3.6	0.43	**22358**			0.77	1.76	0.44	**8099**			2.07	3.69	0.56	**21152**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 12 (continued).

		n= 8			Sugar beets		JaiMi	n= 5			Other crop		JaiMi
Market performance		Variables			Amount	KGS/Unit	KGS/ha	Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha				*tons*	*44.9*								
Hauptleistung:	KGS/t	3			44949.2	3	130914						0
Nebenleistung I	KGS/t												0
Nebenleistung II	KGS/bundle												0
Market performance total							**130914**						**146890**
Proportional variable costs													
Seed					Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha
Own seed													0
Bght-seed	KGS/t	3963			1.00	3963	3963						0
Total costs for seed							**3963**						**0**
Fertilization					Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)	KGS/kg	23.50	50%		212.50	23.50	2497						0
NPK Aquarin, Nutrivant	KGS/kg						0						0
Manure	KGS/t	106.7	38%		28.33	106.67	1133						0
Fertilization total							**3,630**						**0**
Plant protection					Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha
Treatment	KGS/kg						0						0
Herbicide	KGS/Unit	920	63%		1.00	920	575						0
Insecticide (PO China)							0						0
Insecticide (PO KARATE ZEON)							0						0
Fungicide							0						0
Pflanzenschutz gesamt							**575**						**0**
Services				Amoun	Unit/ha	KGS/Unit	KGS/ha			Amoun	Unit/ha	KGS/Unit	KGS/ha
Ploughing													
Diesel	KGS/l	38.0		1.00	30.8	38.0	879						0
Service of contrac	KGS/ha	655	75%	1.00		655	491						0
Harrowing													
Diesel				1.00	10.0	38.0	190						0
Service of contrac	KGS/ha	333	50%	1.00		333	166						0
Distributor (Fertilizer)													
Diesel				1.00	5.00	38.0	24						0
Service of contrac	KGS/ha	310	13%	1.00		310	39						0
Seeding													
Diesel				1.00	10.00	38.0	238						0
Service of contrac	KGS/ha	600	63%	1.00		600	375						0
Sprayer													
Diesel				1.00	5.00	38.0	71						0
Service of contrac	KGS/ha	310	38%	1.00		310	116						0
Harvester (PO/SB Digger)													
Diesel				1.00	38.57	38.0	916						0
Service of contrac	KGS/ha	1880	63%	1.00		1880	1175						0
Truck													
Benzin	KGS/l	31		5.64	12.50	31.3	551						0
Service of contrac	KGS/ha	1613	25%	5.64		1613	2274						0
Mower (Hill up PO)													
Diesel				2.0	8	38.0	361						0
Service of contractor		412	63%	2.0		412.40	516						0
Baler													
Service of contrac	KGS/ha						0						0
Total costs for services							**8381**						**0**
Variable costs of own mechaniz.		KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha	KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
	VC KGS/ha	10672											
Diesel		99%	10611	79%	220	38.0	**8366**						**0**
Benzin		99%	10611	21%	71.9	31.3	**2245**						**0**
Reparatur		1%	61.3		1.00	61.3	**61**						**0**
Total							**10672**						**0**
Total proportional variable costs							**27221**						**0**
Amount of coverage							**103694**						**146890**
Short term assets in average					50%	of var. cost	13610.5						0.0
Costs for capital for short term assets													
				Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha
Own capital		12%		0.88	11909	12%	1429						0
Borrowed capital		10%		0.13	1701	10%	170						0
Total costs for capital							**170**						**0**
Costs for labour													
			Total m	Share	m.h./ha	KGS/h	KGS/ha		Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour	KGS/m.h.	24	580	69%	402	24	9597						0
Wage labour	KGS/m.h.	60	580	31%	178	60	10595						0
							10595						**0**
Costs for land					Share	KGS/ha	KGS				Share	KGS/ha	KGS
Own land	KGS/ha	4750			61%	4750	2878						0
Leased land	KGS/ha	4750			39%	4750	1872						0
Total costs for land							**1872**						**0**
Other production costs							**1975**						
Variable costs II total							**14613**						**0**
Total production costs KGS/ha(ohne AV, fix. Costs)							**41834**						**29219**
Profit KGS/ha (without fix&inderect costs)							**89081**						**117671**
Average Profit total KGS				0.05	0.7	0.07	**4743**			0.06	1.2	0.05	**6755**

	n= 3			Other crop		JaiHi	n= 93			Kitchen garden		JaiMi	n= 63			Kitchen Garden		JaiHi
Market performance	Variables			Amount	KGS/Unit	KGS/ha	Variables			Amount	KGS/Unit	KGS/ha	Variables			Amount	KGS/Unit	KGS/ha
Yield t/ha																		
Hauptleistung:						0						0						0
Nebenleistung I						0						0						0
Nebenleistung II						0						0						0
Market performance total						**40953**						**0**						**0**
Proportional variable costs																		
Seed				Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha
Own seed						0						0						0
Bght-seed						0						0						0
Total costs for seed						**0**						**0**						**0**
Fertilization				Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha
N (Saltpetre 32%, 42%)						0						0						0
NPK Aquarin, Nutrivant						0.0						0						0.0
Manure						0.0						0						0.0
Fertilization total						**0**						**0**						**0**
Plant protection				Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha				Amount	KGS/Unit	KGS/ha
Treatment						0						0						0
Herbicide						0						0						0
Insecticide (PO China)						0						0						0
Insecticide (PO KARATE ZEON)						0						0						0
Fungicide						0						0						0
Pflanzenschutz gesamt						**0**						**0**						**0**
Services			Amoun	Unit	KGS/Unit	KGS/ha			Amoun	Unit/ha	KGS/Unit	KGS/ha			Amoun	Unit	KGS/Unit	KGS/ha
Ploughing																		
Diesel						0						0						0
Service of contrac						0						0						0
Harrowing																		
Diesel						0						0						0
Service of contrac						0						0						0
Distributor (Fertilizer)																		
Diesel						0						0						0
Service of contrac						0						0						0
Seeding																		
Diesel						0						0						0
Service of contrac						0						0						0
Sprayer																		
Diesel						0						0						0
Service of contrac						0						0						0
Harvester (PO/SB Digger)																		
Diesel						0						0						0
Service of contrac						0						0						0
Truck																		
Benzin						0						0						0
Service of contrac						0						0						0
Mower (Hill up PO)																		
Diesel						0						0						0
Service of contractor						0						0						0
Baler																		
Service of contrac						0						0						0
Total costs for services						**0**						**0**						**0**
Variable costs of own mechaniz.	KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha	KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha	KGS/ha	Amoun	Share	Amount	KGS/Unit	KGS/ha
VC KGS/ha																		
Diesel						**0**						**0**						**0**
Benzin						**0**						**0**						**0**
Reparatur						**0**						**0**						**0**
Total						**0**						**0**						**0**
Total proportional variable costs						**0**						**0**						**0**
Amount of coverage						**40953.3**						**0**						**0**
Short term assets in average				50%	of var. cost	0.0						0.0				50%	of var. cost	0.0
Costs for capital for short term assets																		
			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha
Own capital						0						0						0
Borrowed capital						0						0						0
Total costs for capital						**0**						**0**						**0**
Costs for labour																		
		Total m	Share	m.h./ha	KGS/h	KGS/ha		Total m	Share	m.h./ha	KGS/h	KGS/ha		Total m	Share	m.h./ha	KGS/h	KGS/ha
Own labour						0						0						0
Wage labour						0						0						0
						0						**0**						**0**
Costs for land				Share	KGS/ha	KGS				Share	KGS/ha	KGS				Share	KGS/ha	KGS
Own land						0						0						0
Leased land						0						0						0
Total costs for land						**0**						**0**						**0**
Other production costs																		
Variable costs II total						**0**						**0**						**0**
Total production costs KGS/ha(ohne AV, fix. Costs)						**9932**						**0**						**0**
Profit KGS/ha (without fix&inderect costs)						**31022**						**6209**						**1860**
Average Profit total KGS			0.04	1.7	0.02	**1241**				0.2	0.86	**1074**				0.1	0.50	**136**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 13 Detailed gross margin calculation of the raising animals in UJF nd LJF farming systems

		n= 90			Cows		JaiMi	n= 104			Cows		JaiHi
Market performance		Variables		Coeff.	Amount	KGS/Un	KGS/ha	Variables		Coeff.	Amount	KGS/Un	KGS/ha
Yield													
Hauptleistung:	KGS/kg	13.26			1119	13	14838	13.82			1046	14	14454
Nebenleistung I	KGS/Tier	26339		0.5	0.92	26339	12144	23928		0.5	0.92	23928	11031
Nebenleistung II	KGS/Tier	43176			0.11	43176	4873	40125			0.11	40125	4537
Market performance total							**31854.8**						**30021.1**
Bestandsergänzung					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	27411			0.14	27411	3916	25302			0.14	25302	3615
							3916						**3615**
Forage					Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg	13.26			294.03	13.26	3900	13.82			284.04	13.82	3926
Fodder for young animal (Hay)	KGS/kg	7.20			754.29	7.20	5432	6.33			730.08	6.33	4625
Fodder for young animal (Cere	KGS/kg	8.51			134.16	8.51	1142	9.02			146.67	9.02	1323
Fodder for animal (Hay)	KGS/kg	7.20			942.87	7.20	6789	6.33			912.60	6.33	5781
Fodder for animal (Cereals)	KGS/kg	8.51			171.60	8.51	1461	9.02			183.34	9.02	1653
Total costs for fodder							**18,723**						**17,307**
Services					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Herder	KGS/Mont	224	46%		6.27	224	641	163	45%		5.54	163	407
Total services							**641**						**407**
Other costs				Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot	10.0		3.0	1.0	10.0	30	10.0		3.0	1.0	10.0	30
Blutprobe	KGS/LU	80.0		1.0	1.0	80.0	80	80.0		1.0	1.0	80.0	80
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.20	280	112	280		2.00	0.20	280	112
Fee for pasture using	KGS/a, LU	60		1.00	1.00	60	60	40		1.00	1.00	40	40
Salt		12		12	1.00	12	144	10		12	1.00	10	120
Total other costs							**426**						**382**
Total proportional variable costs							**23706**						**21711**
Amount of coverage							**8149**						**8310**
Short term assets in average							27411						25302
Costs for capital for short term assets													
				Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha
Own capital		12%		0.94	25857	12%	3103	12%		0.96	24338	12%	2921
Borrowed capital		19%		0.06	1555	19%	298	18%		0.04	964	18%	172
Total costs for capital							**298**						**172**
Variable costs II total							**298**						**172**
Total production costs KGS/ha(ohne AV, fix. Costs)							**24004**						**21883**
Profit KGS/ha (without fix&inderect costs)							**7851**						**8138**
Profit total KGS					2.6	0.83	**16864**				2.5	0.83	**16797**

		n= 11			Fattened Cattle <		JaiMi	n= 8			Fattened Cattle <		JaiHi
Market performance		Variables			Amount	KGS/Un	KGS/ha	Variables			Amount	KGS/Un	KGS/ha
Yield													
Hauptleistung:	KGS/kg	42364			1	42364	42364	34625			1	34625	34625
Nebenleistung I	KGS/Tier												
Nebenleistung II	KGS/Tier												
Market performance total							**42363.6**						**34625**
Bestandsergänzung					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	18748			0.90	18748	16873	17781			0.90	17781	16003
							16873						**16003**
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha		Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg												
Fodder for young animal (Hay)	KGS/kg	7.20	30.5	2.64	15.45	7.20	8948	6.33	30.5	2.00	18.38	6.33	7100
Fodder for young animal (Cere	KGS/kg	8.51	30.5	2.64	6.73	8.51	4604	9.02	30.5	2.00	6.50	9.02	3575
Fodder for animal (Hay)	KGS/kg												
Fodder for animal (Cereals)	KGS/kg												
Total costs for fodder							**13,552**						**10,675**
Services					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Herder	KGS/Mont												
Total services							**0**						**0**
Other costs				Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot	10.0		3.0	1.0	10.0	30	10.0		3.0	1.0	10.0	30
Blutprobe	KGS/LU	80.0		1.0	1.0	80.0	80	80.0		1.0	1.0	80.0	80
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.20	280	112	280		2.00	0.20	280	112
Fee for pasture using	KGS/a, LU	60		1.00	1.00	60	60	40		1.00	1.00	40	40
Salt		12		2.64	1.00	12	32	10		2.00	1.00	10	20
Total other costs							**314**						**282**
Total proportional variable costs							**30739**						**26960**
Amount of coverage							**11624**						**7665**
Short term assets in average							18748						17781
Costs for capital for short term assets													
				Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha
Own capital		12%		0.93	17414	12%	2090	12%		0.99	17687	12%	2122
Borrowed capital		10%		0.07	1334	10%	133	21%		0.01	95	21%	19
Total costs for capital							**133**						**19.4**
Variable costs II total							**133**						**19.41**
Total production costs KGS/ha(ohne AV, fix. Costs)							**30873**						**26980**
Profit KGS/ha (without fix&inderect costs)							**11491**						**7645**
Profit total KGS					2.9	0.10	**3405**				2.0	0.06	**979**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 13 (continued).

		n= 18			Fattened Cattle >JaiMi			n= 17			Fattened Cattle >JaiHi			n= 86			Mare		JaiMi	n= 106			Mare		JaiHi
Market performance		Variables			Amount	KGS/Un	KGS/ha	Variables			Amount	KGS/Un	KGS/ha	Variables		Coeff.	Amount	KGS/Un	KGS/ha	Variables		Coeff.	Amount	KGS/Un	KGS/ha
Yield																									
Hauptleistung:	KGS/kg	50539			1	50539	50539	50753			1	50753	50753	14.50		2%	137	15	46	24.44		9%	305	24	703
Nebenleistung I	KGS/Tier													29000			0.90	29000	26100	27222			0.90	27222	24500
Nebenleistung II	KGS/Tier													58844			0.11	58844	6649	63800			0.11	63800	7209
Market performance total							**50538.9**						**50752.9**						**32795.6**						**32412.8**
Bestandsergänzung					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	29045			0.90	29045	26140	32634			0.90	32634	29371	35156			0.13	35156	4395	35294			0.13	35294	4412
							26140						**29371**						**4395**						**4412**
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha		Day/M	Mastd	Amount	KGS/kg	KGS/ha		Length	In Barn	Amount	KGS/kg	KGS/ha		Length	In Barn	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg													14.50			0.00	14.50	0	24.44			0.00	24.44	0
Fodder for young animal (Hay)	KGS/kg	7.20	30.5	2.75	15.81	7.20	9547	6.33	30.5	2.09	15.85	6.33	6404	7.20	10.58	43.21	6.63	7.20	2062	6.33	9.60	73.32	6.80	6.33	3158
Fodder for young animal (Cere	KGS/kg	8.51	30.5	2.75	7.00	8.51	4997	9.02	30.5	2.09	6.17	9.02	3546	8.51	10.58	43.21	4.07	8.51	1496	9.02	9.60	73.32	3.98	9.02	2632
Fodder for animal (Hay)	KGS/kg													7.20	10.58	43.21	12.89	7.20	4010	6.33	9.60	73.32	13.22	6.33	6141
Fodder for animal (Cereals)	KGS/kg													8.51	10.58	43.21	7.57	8.51	2783	9.02	9.60	73.32	5.56	9.02	3675
Total costs for fodder							**14,545**						**9,950**						**10,352**						**15,606**
Services					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal													258.8	56%		6.5	259	937	207.7	25%		7	208	368
Total services							**0**						**0**						**937**						**368**
Other costs				Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot	10.0		3.0	1.0	10.0	30	10.0		3.0	1.0	10.0	30	10.0		3.0	1.0	10.0	30	10.0		3.0	1.0	10.0	30
Blutprobe	KGS/LU	80.0		1.0	1.0	80.0	80	80.0		1.0	1.0	80.0	80	80.0		0.5	1.0	80.0	40	80.0		1.0	1.0	80.0	80
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.20	280	112	280		2.00	0.20	280	112	280		2.00	0.20	280	112	280		2.00	0.20	280	112
Fee for pasture using	KGS/a, LU	60		1.00	1.00	60	60	40		1.00	1.00	40	40	60		1.00	1.00	60	60	40		1.00	1.00	40	40
Salt		12		2.75	1.00	12	33	10		2.09	1.00	10	21	12		12	1.00	12	144	10		12	1.00	10	120
Total other costs							**315**						**283**						**386**						**382**
Total proportional variable costs							**41000**						**39604**						**16069**						**20768**
Amount of coverage							**9539**						**11149**						**16726**						**11645**
Short term assets in average							29045						32634						35156						35294
Costs for capital for short term assets																									
				Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha
Own capital		12%		0.94	27355	12%	3283	12%		0.94	30736	12%	3688	12%		0.95	33554	12%	4026	12%		0.96	33833	12%	4060
Borrowed capital		23%		0.06	1690	23%	380	17%		0.06	1899	17%	326	17%		0.05	1602	17%	266	18%		0.04	1461	18%	260
Total costs for capital							**380**						**326**						**266**						**260**
Variable costs II total							**380**						**326**						**266**						**260**
Total production costs KGS/ha(ohne AV, fix. Costs)							**41380**						**39930**						**16335**						**21028**
Profit KGS/ha (without fix&inderect costs)							**9159**						**10823**						**16460**						**11385**
Profit total KGS					2.1	0.17	**3138**				1.6	0.14	**2338**				2.2	0.80	**28805**				2.5	0.85	**23953**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 13 (continued).

		n= 18			Young animal 1-: JaiMi			n= 15			Young animal 1-: JaiHi			n= 43			Horses >2(no Ma JaiMi			n= 23			Horses >2(no Ma JaiHi		
Market performance		Variables			Amount	KGS/Un	KGS/ha	Variables			Amount	KGS/Un	KGS/ha	Variables			Amount	KGS/Un	KGS/ha	Variables			Amount	KGS/Un	KGS/ha
Yield																									
Hauptleistung:	KGS/kg	35156			1	35156	35156	35294			1	35294	35294	58844			1	58844	58844	63800			1	63800	63800
Nebenleistung I	KGS/Tier																								
Nebenleistung II	KGS/Tier																								
Market performance total							**35156.3**						**35294.1**						**58843.8**						**63800**
Bestandsergänzung					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	29000			0.90	29000	26100	27222			0.90	27222	24500	35156			0.90	35156	31641	35294			0.90	35294	31765
							26100						**24500**						**31641**						**31765**
Forage			Length	In Barn	Amount	KGS/kg	KGS/ha		Length	In Barn	Amount	KGS/kg	KGS/ha		Length	In Barn	Amount	KGS/kg	KGS/ha		Length	In Barn	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg																								
Fodder for young animal (Hay)	KGS/kg	7.20	10.58	43.21	7.37	7.20	2292	6.33	9.60	73.32	7.56	6.33	3509	7.20						6.33					
Fodder for young animal (Cere	KGS/kg	8.51	10.58	43.21	4.52	8.51	1663	9.02	9.60	73.32	4.42	9.02	2924	8.51						9.02					
Fodder for animal (Hay)	KGS/kg													7.20	10.58	43.21	12.89	7.20	4010	6.33	9.60	73.32	13.22	6.33	6141
Fodder for animal (Cereals)	KGS/kg													8.51	10.58	43.21	7.57	8.51	2783	9.02	9.60	73.32	5.56	9.02	3675
Total costs for fodder							**3,954**						**6,433**						**6,793**						**9,816**
Services					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Herder	KGS/Mont	258.8	56%		6.5	259	937	207.7	25%		7	208	368	258.8	56%		6.5	259	937	207.7	25%		7	208	368
Total services							**937**						**368**						**937**						**368**
Other costs				Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot	10.0		3.0	1.0	10.0	30	10.0		3.0	1.0	10.0	30	10.0		3.0	1.0	10.0	30	10.0		3.0	1.0	10.0	30
Blutprobe	KGS/LU	80.0		0.5	1.0	80.0	40	80.0		1.0	1.0	80.0	80	80.0		0.5	1.0	80.0	40	80.0		1.0	1.0	80.0	80
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.20	280	112	280		2.00	0.20	280	112	280		2.00	0.20	280	112	280		2.00	0.20	280	112
Fee for pasture using	KGS/a, LU	60		1.00	1.00	60	60	40		1.00	1.00	40	40	60		1.00	1.00	60	60	40		1.00	1.00	40	40
Salt		12		12	1.00	12	144	10		12	1.00	10	120	12		12	1.00	12	144	10		12	1.00	10	120
Total other costs							**386**						**382**						**386**						**382**
Total proportional variable costs							**31377**						**31684**						**39756**						**42331**
Amount of coverage							**3779**						**3611**						**19087**						**21469**
Short term assets in average							29000						27222						35156						35294
Costs for capital for short term assets																									
				Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha
Own capital		12%		0.95	27678	12%	3321	12%		0.96	26095	12%	3131	12%		0.95	33554	12%	4026	12%		0.96	33833	12%	4060
Borrowed capital		17%		0.05	1322	17%	220	18%		0.04	1127	18%	201	17%		0.05	1602	17%	266	18%		0.04	1461	18%	260
Total costs for capital							**220**						**201**						**266**						**260**
Variable costs II total							**220**						**201**						**266**						**260**
Total production costs KGS/ha(ohne AV, fix. Costs)							**31597**						**31884**						**40023**						**42591**
Profit KGS/ha (without fix&inderect costs)							**3560**						**3410**						**18821**						**21209**
Profit total KGS					2.3	0.17	**1384**				1.7	0.12	**709**				3.1	0.40	**23526**				1.9	0.18	**7466**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 13 (continued).

		n= 6			Fattened horses JaiHi		
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg	39917			1	39917	39917
Nebenleistung I	KGS/Tier						
Nebenleistung II	KGS/Tier						
Market performance total							**39916.7**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	24953			0.90	24953	22458
							22458
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	7.20					
Fodder for young animal (Cere	KGS/kg	8.51					
Fodder for animal (Hay)	KGS/kg	7.20	30.50	1.83	14.83	7.20	5973
Fodder for animal (Cereals)	KGS/kg	8.51	30.50	1.83	8.33	8.51	3966
Total costs for fodder							**9,939**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal						
Total services							**0**
Other costs				Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot						0
Blutprobe	KGS/LU						0
Medicines (IVERMEK 100 r	KGS/bottle						0
Fee for pasture using	KGS/a, LU						0
Salt		12		1.83	1.00	12	22
Total other costs							**22**
Total proportional variable costs							**32418**
Amount of coverage							**7498**
Short term assets in average							24953
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		1.00	24953	12%	2994
Borrowed capital		0%		0.00	0	0%	0
Total costs for capital							**0**
Variable costs II total							**0**
Total production costs KGS/ha(ohne AV, fix. Costs)							**32418**
Profit KGS/ha (without fix&inderect costs)							**7498**
Profit total KGS					2.8	0.06	**1180**

		n= 2			Fattened horses JaiHi		
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg	57500			1	57500	57500
Nebenleistung I	KGS/Tier						
Nebenleistung II	KGS/Tier						
Market performance total							**57500**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	35228			0.90	35228	31705
							31705
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	6.33					
Fodder for young animal (Cere	KGS/kg	9.02					
Fodder for animal (Hay)	KGS/kg	6.33	30.50	2.00	17.00	6.33	6569
Fodder for animal (Cereals)	KGS/kg	9.02	30.50	2.00	11.00	9.02	6050
Total costs for fodder							**12,619**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal						
Total services							**0**
Other costs				Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot						0
Blutprobe	KGS/LU						0
Medicines (IVERMEK 100 r	KGS/bottle						0
Fee for pasture using	KGS/a, LU						0
Salt		10		2.00	1.00	10	20
Total other costs							**20**
Total proportional variable costs							**44344**
Amount of coverage							**13156**
Short term assets in average							35228
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		1.00	35228	12%	4227
Borrowed capital		0%		0.00	0	0%	0
Total costs for capital							**0**
Variable costs II total							**0**
Total production costs KGS/ha(ohne AV, fix. Costs)							**44344**
Profit KGS/ha (without fix&inderect costs)							**13156**
Profit total KGS					1.5	0.02	**316**

		n= 10			Fattened horses JaiHi		
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg	74600			1	74600	74600
Nebenleistung I	KGS/Tier						
Nebenleistung II	KGS/Tier						
Market performance total							**74600**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	47605			0.90	47605	42844
							42844
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	7.20					
Fodder for young animal (Cere	KGS/kg	8.51					
Fodder for animal (Hay)	KGS/kg	7.20	30.50	1.90	17.60	7.20	7344
Fodder for animal (Cereals)	KGS/kg	8.51	30.50	1.90	8.20	8.51	4044
Total costs for fodder							**11,389**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal						
Total services							**0**
Other costs				Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot						0
Blutprobe	KGS/LU						0
Medicines (IVERMEK 100 r	KGS/bottle						0
Fee for pasture using	KGS/a, LU						0
Salt		12		1.90	1.00	12	23
Total other costs							**23**
Total proportional variable costs							**54256**
Amount of coverage							**20344**
Short term assets in average							47605
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		1.00	47605	12%	5713
Borrowed capital		0%		0.00	0	0%	0
Total costs for capital							**0**
Variable costs II total							**0**
Total production costs KGS/ha(ohne AV, fix. Costs)							**54256**
Profit KGS/ha (without fix&inderect costs)							**20344**
Profit total KGS					1.3	0.09	**2449**

		n= 6			Fattened horses JaiHi		
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg	62500			1	62500	62500
Nebenleistung I	KGS/Tier						
Nebenleistung II	KGS/Tier						
Market performance total							**62500**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	46368			0.90	46368	41731
							41731
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	6.33					
Fodder for young animal (Cere	KGS/kg	9.02					
Fodder for animal (Hay)	KGS/kg	6.33	30.50	2.42	15.25	6.33	7120
Fodder for animal (Cereals)	KGS/kg	9.02	30.50	2.42	7.67	9.02	5095
Total costs for fodder							**12,215**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal						
Total services							**0**
Other costs				Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot						0
Blutprobe	KGS/LU						0
Medicines (IVERMEK 100 r	KGS/bottle						0
Fee for pasture using	KGS/a, LU						0
Salt		10		2.42	1.00	10	24
Total other costs							**24**
Total proportional variable costs							**53971**
Amount of coverage							**8529**
Short term assets in average							46368
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.90	41858	12%	5023
Borrowed capital		16%		0.10	4510	16%	722
Total costs for capital							**722**
Variable costs II total							**722**
Total production costs KGS/ha(ohne AV, fix. Costs)							**54693**
Profit KGS/ha (without fix&inderect costs)							**7807**
Profit total KGS					1.0	0.05	**375**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 13 (continued).

		n= 101			Sheep		JaiMi
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg						
Nebenleistung I	KGS/Tier	3903			0.94	3903	3669
Nebenleistung II	KGS/Tier	5610			0.14	5610	785
Market performance total							**4454.64**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	5049			0.20	5049	1010
							1010
Forage					Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	7.20			95.68	7.20	689
Fodder for young animal (Cere	KGS/kg	8.51			17.60	8.51	150
Fodder for animal (Hay)	KGS/kg	7.20			139.42	7.20	1004
Fodder for animal (Cereals)	KGS/kg	8.51			24.64	8.51	210
Total costs for fodder							**2,052**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Mont	32.3			6.3	32	203
Total services							**203**
Other costs				Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot	10.0		2.0	1.0	10.0	20
Blutprobe	KGS/LU						
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.05	280	28
Fee for pasture using	KGS/a, LU	15		1.00	1.00	15	15
Salt		12.0		12.00	0.40	12	58
Total other costs							**121**
Total proportional variable costs							**3385**
Amount of coverage							**1069**
Short term assets in average							5049
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.94	4769	12%	572
Borrowed capital		18%		0.06	280	18%	51
Total costs for capital							**51**
Variable costs II total							**51**
Total production costs KGS/ha(ohne AV, fix. Costs)							**3436**
Profit KGS/ha (without fix&inderect costs)							**1018**
Profit total KGS					25.1	0.94	**23926**

		n= 121			Sheep		JaiHi
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg						
Nebenleistung I	KGS/Tier	3905			0.94	3905	3671
Nebenleistung II	KGS/Tier	5667			0.14	5667	793
Market performance total							**4464**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	5100			0.20	5100	1020
							1020
Forage					Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	6.33			82.74	6.33	524
Fodder for young animal (Cere	KGS/kg	9.02			18.61	9.02	168
Fodder for animal (Hay)	KGS/kg	6.33			121.52	6.33	770
Fodder for animal (Cereals)	KGS/kg	9.02			26.05	9.02	235
Total costs for fodder							**1,696**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Mont	32.6			6	33	180
Total services							**180**
Other costs				Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot	10.0		2.0	1.0	10.0	20
Blutprobe	KGS/LU						
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.05	280	28
Fee for pasture using	KGS/a, LU	10		1.00	1.00	10	10
Salt		10.0		12.00	0.40	10	48
Total other costs							**106**
Total proportional variable costs							**3003**
Amount of coverage							**1461**
Short term assets in average							5100
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.96	4882	12%	586
Borrowed capital		18%		0.04	218	18%	38
Total costs for capital							**38**
Variable costs II total							**38**
Total production costs KGS/ha(ohne AV, fix. Costs)							**3041**
Profit KGS/ha (without fix&inderect costs)							**1423**
Profit total KGS					27.4	0.97	**37786**

		n= 22			Fattened sheep ‹ JaiMi		
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg						
Nebenleistung I	KGS/Tier	5123			1.00	5123	5123
Nebenleistung II	KGS/Tier						
Market performance total							**5122.73**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	4168			0.75	4168	3126
							3126
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	7.20	30.50	2.80	2.04	7.20	1252
Fodder for young animal (Cere	KGS/kg	8.51	30.50	2.80	0.47	8.51	343
Fodder for animal (Hay)	KGS/kg						
Fodder for animal (Cereals)	KGS/kg						
Total costs for fodder							**1,595**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Mont						
Total services							**0**
Other costs				Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot						
Blutprobe	KGS/LU						
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.05	280	28
Fee for pasture using	KGS/a, LU	15		1.00	1.00	15	15
Salt		12.0		2.80	0.40	12	13
Total other costs							**56**
Total proportional variable costs							**4778**
Amount of coverage							**345**
Short term assets in average							4168
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.96	3996	12%	479
Borrowed capital		15%		0.04	172	15%	25
Total costs for capital							**25**
Variable costs II total							**25**
Total production costs KGS/ha(ohne AV, fix. Costs)							**4803**
Profit KGS/ha (without fix&inderect costs)							**320**
Profit total KGS					7.2	0.20	**468**

		n= 19			Fattened sheep ‹ JaiHi		
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg						
Nebenleistung I	KGS/Tier	5332			1.00	5332	5332
Nebenleistung II	KGS/Tier						
Market performance total							**5332**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	3961			0.75	3961	2970
							2970
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	6.33	30.50	2.89	2.10	6.33	1174
Fodder for young animal (Cere	KGS/kg	9.02	30.50	2.89	0.56	9.02	442
Fodder for animal (Hay)	KGS/kg						
Fodder for animal (Cereals)	KGS/kg						
Total costs for fodder							**1,616**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Mont						
Total services							**0**
Other costs				Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot						
Blutprobe	KGS/LU						
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.05	280	28
Fee for pasture using	KGS/a, LU	10		1.00	1.00	10	10
Salt		10.0		2.89	0.40	10	12
Total other costs							**50**
Total proportional variable costs							**4636**
Amount of coverage							**695**
Short term assets in average							3961
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.98	3885	12%	466
Borrowed capital		19%		0.02	76	19%	14
Total costs for capital							**14**
Variable costs II total							**14**
Total production costs KGS/ha(ohne AV, fix. Costs)							**4651**
Profit KGS/ha (without fix&inderect costs)							**681**
Profit total KGS					3.9	0.15	**403**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 13 (continued).

		n= 34		Fattened sheep : JaiMi			
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg						
Nebenleistung I	KGS/Tier	6600			1.00	6600	6600
Nebenleistung II	KGS/Tier						
Market performance total							**6600**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	5610			0.75	5610	4208
							4208
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	7.20					
Fodder for young animal (Cere	KGS/kg	8.51					
Fodder for animal (Hay)	KGS/kg	7.20	30.50	2.85	2.20	7.20	1375
Fodder for animal (Cereals)	KGS/kg	8.51	30.50	2.85	0.52	8.51	384
Total costs for fodder							**1,759**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal						
Total services							**0**
Other costs				Amour	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot						
Blutprobe	KGS/LU						
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.05	280	28
Fee for pasture using	KGS/a, LU	15		1.00	1.00	15	15
Salt		12.0		2.85	0.40	12	14
Total other costs							**57**
Total proportional variable costs							**6024**
Amount of coverage							**576**
Short term assets in average							5610
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.95	5330	12%	640
Borrowed capital		16%		0.05	280	16%	45
Total costs for capital							**45**
Variable costs II total							**45**
Total production costs KGS/ha(ohne AV, fix. Costs)							**6069**
Profit KGS/ha (without fix&inderect costs)							**531**
Profit total KGS					7.3	0.31	**1220**

		n= 27		Fattened sheep : JaiHi			
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg						
Nebenleistung I	KGS/Tier	7663			1.00	7663	7663
Nebenleistung II	KGS/Tier						
Market performance total							**7663**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	5667			0.80	5667	4533
							4533
Forage			Day/M	Mastd	Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	6.33					
Fodder for young animal (Cere	KGS/kg	9.02					
Fodder for animal (Hay)	KGS/kg	6.33	30.50	2.90	2.10	6.33	1176
Fodder for animal (Cereals)	KGS/kg	9.02	30.50	2.90	0.57	9.02	450
Total costs for fodder							**1,626**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal						
Total services							**0**
Other costs				Amour	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot						
Blutprobe	KGS/LU						
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.05	280	28
Fee for pasture using	KGS/a, LU	10		1.00	1.00	10	10
Salt		10.0		2.90	0.40	10	12
Total other costs							**50**
Total proportional variable costs							**6209**
Amount of coverage							**1454**
Short term assets in average							5667
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.97	5491	12%	659
Borrowed capital		18%		0.03	176	18%	32
Total costs for capital							**32**
Variable costs II total							**32**
Total production costs KGS/ha(ohne AV, fix. Costs)							**6241**
Profit KGS/ha (without fix&inderect costs)							**1421**
Profit total KGS					5.0	0.22	**1535**

		n= 42		Goats		JaiMi	
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg	1205			0.09	1205	113
Nebenleistung I	KGS/Tier	3300			0.20	3300	660
Nebenleistung II	KGS/Tier	2043			1.44	2043	2942
Market performance total							**3714.69**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	2970			0.20	2970	594
							594
Forage					Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	7.20			89.10	7.20	642
Fodder for young animal (Cere	KGS/kg	8.51			16.59	8.51	141
Fodder for animal (Hay)	KGS/kg	7.20			124.74	7.20	898
Fodder for animal (Cereals)	KGS/kg	8.51			23.23	8.51	198
Total costs for fodder							**1,879**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal	32.3			6.3	32	203
Total services							**203**
Other costs				Amour	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot	10.0		2.0	1.0	10.0	20
Blutprobe	KGS/LU						
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.05	280	28
Fee for pasture using	KGS/a, LU	15		1.00	1.00	15	15
Salt		12.0		12.00	0.40	12	58
Total other costs							**121**
Total proportional variable costs							**2796**
Amount of coverage							**919**
Short term assets in average							2970
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.79	2334	12%	280
Borrowed capital		19%		0.21	636	19%	121
Total costs for capital							**121**
Variable costs II total							**121**
Total production costs KGS/ha(ohne AV, fix. Costs)							**2917**
Profit KGS/ha (without fix&inderect costs)							**798**
Profit total KGS					6.8	0.39	**2112**

		n=	84	Goats		JaiHi	
Market performance		Variables			Amount	KGS/Un	KGS/ha
Yield							
Hauptleistung:	KGS/kg	1247			0.18	1247	218
Nebenleistung I	KGS/Tier	2948			0.20	2948	590
Nebenleistung II	KGS/Tier	2000			1.44	2000	2880
Market performance total							**3688**
Bestandsergänzung					Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	2653			0.20	2653	531
							531
Forage					Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg						
Fodder for young animal (Hay)	KGS/kg	6.33			89.03	6.33	564
Fodder for young animal (Cere	KGS/kg	9.02			20.59	9.02	186
Fodder for animal (Hay)	KGS/kg	6.33			121.76	6.33	771
Fodder for animal (Cereals)	KGS/kg	9.02			27.23	9.02	246
Total costs for fodder							**1,766**
Services					Amount	KGS/Un	KGS/ha
Herder	KGS/Month, Animal	32.6			5.5	33	180
Total services							**180**
Other costs				Amour	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot	10.0		2.0	1.0	10.0	20
Blutprobe	KGS/LU						
Medicines (IVERMEK 100 r	KGS/bottle	280		2.00	0.05	280	28
Fee for pasture using	KGS/a, LU	10		1.00	1.00	10	10
Salt		10.0		12.00	0.40	10	48
Total other costs							**106**
Total proportional variable costs							**2584**
Amount of coverage							**1104**
Short term assets in average							2653
Costs for capital for short term assets							
				Share	Amount	%	KGS/ha
Own capital		12%		0.82	2162	12%	259
Borrowed capital		18%		0.18	490	18%	86
Total costs for capital							**86**
Variable costs II total							**86**
Total production costs KGS/ha(ohne AV, fix. Costs)							**2670**
Profit KGS/ha (without fix&inderect costs)							**1018**
Profit total KGS					9.6	0.67	**6589**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Table A 13 (continued).

		n= 2		Yak			JaiMi	n= 6		Yak			JaiHi	n= 79		Poultry			JaiMi	n= 56		Poultry			JaiHi	n= 3		Apiary			JaiMi
Market performance		Variables		Coeff.	Amount	KGS/Un	KGS/ha	Variables		Coeff.	Amount	KGS/Un	KGS/ha	Variables			Amount	KGS/Un	KGS/ha	Variables			Amount	KGS/Un	KGS/ha	Variables			Amount	KGS/Un	KGS/ha
Yield																															
Hauptleistung:	KGS/kg													5			85.44	5	427	5			75.00	5	375	250			100.00	250	25000
Nebenleistung I	KGS/Tier	14750		0.5	0.70	14750	5163	14750		0.5	0.70	14750	5163	300			0.90	300	270	300			0.90	300	270						
Nebenleistung II	KGS/Tier	38750			0.10	38750	3875	35000			0.10	35000	3500																		
Market performance total							**9037.5**						**8662.5**						**697**						**645**						**25000**
Bestandsergänzung					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Heifer	KGS/Tier	14750			0.14	14750	2107	14750			0.14	14750	2107	300			0.14	300	43	300			0.14	300	43						
							2107						**2107**						**43**						**43**						**0**
Forage					Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha				Amount	KGS/kg	KGS/ha
Milk for calves	KGS/kg																														
Fodder for young animal (Hay)	KGS/kg																														
Fodder for young animal (Cere	KGS/kg																														
Fodder for animal (Hay)	KGS/kg																														
Fodder for animal (Cereals)	KGS/kg													8.51			36.50	8.51	311	9.02			36.50	9.02	329	42			100.00	42.00	4200
Total costs for fodder																			**311**						**329**						**4,200**
Services					Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha				Amount	KGS/Un	KGS/ha
Herder	KGS/Mont	150			12.00	150	1800	100			12.00	100	1200																		
Total services							**1800**						**1200**						**0**						**0**						**0**
Other costs				Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha			Amou	Unit	KGS/Un	KGS/ha
Veterinarian	KGS/Shot																														
Blutprobe	KGS/LU																														
Medicines (IVERMEK 100 r	KGS/bottle																														
Fee for pasture using	KGS/a, LU																														
Salt																										25000		0.40	1.00	25000	10000
Total other costs							**0**						**0**						**0**						**0**						**10000**
Total proportional variable costs							**3907**						**3307**						**354**						**372**						**14200**
Amount of coverage							**5130**						**5355**						**344**						**273**						**10800**
Short term assets in average							14750						14750						300						300						0
Costs for capital for short term assets																															
				Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha			Share	Amount	%	KGS/ha
Own capital		12%		0.81	11939	12%	1433	12%		0.95	13974	12%	1677						0						0						0
Borrowed capital		18%		0.19	2811	18%	492	24%		0.05	776	24%	186						0						0						0
Total costs for capital							**492**						**186**						**0**						**0**						**0**
Variable costs II total							**492**						**186**						**0**						**0**						**0**
Total production costs KGS/ha(ohne AV, fix. Costs)							**4399**						**3493**						**354**						**372**						**14200**
Profit KGS/ha (without fix&inderect costs)							**4638**						**5169**						**344**						**273**						**10800**
Profit total KGS					16.0	0.02	**1374**				9.0	0.05	**2233**				13.9	0.63	**3022**				12.2	0.45	**1490**				1.0	0.02	**259**

Average exchange rate in 2013, 1.00 USD = 47.8 Kyrgyz som (KGS) (adapted from www.oanda.com)

Appendix 7 List of publications, manuscripts and conference contributions in the framework of this Ph.D. study

Published research articles:

Azarov A, Maurer MK, Weyerhaeuser H, Darr D. 2019. The impact of uncertainty on smallholder farmers' income in Kyrgyzstan. Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS) **120**: 183–195, doi:10.17170/kobra-20191127816.

Azarov A, Polesny Z, Darr D, Kulikov M, Verner V, Sidle RC. 2022. Classification of Mountain Silvopastoral Farming Systems in Walnut Forests of Kyrgyzstan: Determining Opportunities for Sustainable Livelihoods. Agriculture, **12** (12):2004.

Submitted research articles:

Azarov A, Polesny Z, Darr D, Verner V, Sidle RC. Farming systems classification for the assessment of sustainable development pathways in the Tien Shan Mountains of Kyrgyzstan. **Submitted** to Mountain Research and Development.

Kulikov M, Shibkov E, Isaev E, **Azarov** A, Sidle RC. 2023. Spatio-temporal patterns of different forest type response to climatic factors. **Submitted** to the Central Asian Journal of Sustainability and Climate Research**.**

Other publications (not peer-reviewed):

Azarov A, Polesny Z, Verner V, Darr D. 2020. Characteristics and Profitability of Livestock-based Farming Systems in At-Bashy, Naryn Oblast. MSRI's Research paper series (#6). Bishkek. Available from https://ucentralasia.org/publications/2020/april/characteristics-and-profitability-of-livestock-based-farming-systems-in-at-bashy-naryn-oblast (accessed December 2022)

Conferences and seminars:

Azarov A, Polesny Z, Darr D, Verner V, Sidle CR. 2021. Typological characterization of livestock-based farming systems to determine sustainable development pathways in Kyrgyzstan. The 7th Annual 'Life in Kyrgyzstan' Conference. Oral session on Agriculture and Climate Change. (https://lifeinkyrgyzstan.org/conference/lik-conference-2021/).

Azarov A, Polesny Z, Darr D, Verner V, Sidle CR. 2022. 'Typological characterisation of smallholder silvopastoral farms in the walnut-fruit forests in Kyrgyzstan'. Tropentag 2022: Can agroecological farming feed the world? Farmers' and academia's views. Poster session on Economic Potential of Agroecology.

Azarov A, Kulikov M., Polesny Z., Darr D., Verner V., Sidle C., R., 2022. 'Analysis of livelihood strategies of silvopastoral households in walnut-fruit forests of Kyrgyzstan'. The 8th Annual 'Life in Kyrgyzstan' Conference. Oral session on 'Biodiversity Conservation and Natural Resources' (https://lifeinkyrgyzstan.org/conferences/lik-conference-2022/).

Appendix 8: Photos from the data collection-conducting interviews

Fig. Conducting interview with local farmer, Kara-Alma (2021)

Fig. Conducting interview with local farmer, At-Bashy (2014)

Fig. Conducting interview with local experts, Kashka-Suu (2021)

Fig. Conducting interview with local experts, Suusamyr (2014)

Fig. Horses grazing in forest pasture , Kara-Alma (2021)

Fig. Sheep herd grazing in highland summer pasture 'jailoo', Chong- Kemin (2014)

Appendix 9: Photos from the data collection-grazing sytem

Fig. Driving animals to highland pastures by professional herders (2014)

Fig. Summer camp of professional herders in Ardakty highland pasture (2014)

Fig. Grazing animals in forest near villages in winter, Arkyt (2021)

Fig. Grazing animals in pastures near villages in winter, Chong-Kemin (2014)

Fig. Grazing animals on arable land and kitchen gardens after harvesting in Kochkor (Nov. 2013)

Fig. Driving dairy cows to arable land and meadows near the settlements, At-Bashy (March 2014)

Appendix 10: Photos from the data collection- feedstuff, animals conditon and pasture degradation

Fig. Typical soviet agricultural machinery of farmers, Chong-Kemin (2014)

Fig. Transporting hay from meadows, At-Bashy (2014)

Fig. Farmers' winter feed stocks, Arkyt (2021)

Fig. Animals that have become emaciated during the winter, Chong-Kemin (2014)

Fig. Soil erosion in forest pastures through trampling, Arkyt (2021)

Fig. Soil erosion in pastures near the villages through trampling, Kochkor (2014)

Appendix 11: Photos from the data collection – processing of agricultural products, handicrafts, tourist camps and livestock market

Fig. Milk processing (salty cheese 'kurut' in Kyrg.), Arkyt (2021)

Fig. Manufacturing a felt carpet, Kochkor (2014)

Fig. An apiary in Arkyt (2021)

Fig. Tourist campsite at the Sary Chelek mountain lake (2021)

Fig. Typical livestock market/souk, Kochkor (2014)

Fig. Hay and straw for sale, Suusamyr (2014)

Appendix 12: Photos from the data collection- endangered species

Fig. *Crataegus knorringiana* is one of endangered NTFP species

Fig. *Malus niedzwetzkyana* is one of endangered NTFP species

Fig. A wild apple tree constantly damaged by livestock (2021)

Fig. *Pyrus turcomanica* is one of edangered NTFP species

Fig. The end of the grazing season at Song-Kul mountain lake (Sept. 2014)

Fig. Author during fieldwork in 'Ardakty jailoo' highland pasture (2014)

Appendix 13: Author's Curriculum Vitae

Name: Azamat Azarov

Nationality: Kyrgyz Republic

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ORCID: https://orcid.org/0000-0001-6398-9643

EDUCATION:

Ph.D. in Sustainable Rural Development in the Tropics And Subtropics - Czech University of Life Sciences Prague (2018 – 2023*anticipated)

MBA in International Agricultural Management - University of Applied Sciences Weihenstephan Triesdorf, Germany (2009 - 2011)

Dilpoma in Agricultural Enterprise Management - Kyrgyz National Agrarian University, Bishkek (2008 - 2011)

PROFESSIONAL EMPLOYMENT:

Research fellow - University of Central Asia, Mountain Society Research Institute (May 2013 – present)

Lecturer and translation assistant - Kyrgyz National Agrarian University, Faculty of innovative technologies/Master course ‚Agricultural Management' (Oct. 2012 – Apr. 2013)

WORKING EXPERIENCE:

Project name**: Conservation and Research of Wild Fruit Species in Western Tian Shan.** Project owner: University of Central Asia/Mountain Societies Research Institute (UCA MSRI)**.** Project funder: The Critical Ecosystem Partnership Fund **(CEPF).**

- Duties: research and development of academic products- (2020-2022).

Project name**: Qualitative study on 'Gender Action Learning System' implementation in Kyrgyzstan.** Project owner: University of Central Asia, Institute of Public Policy and Administration/Mountain Societies Research Institute (UCA IPPA/MSRI)**.** Project funder: International Fund for Agricultural Development **(IFAD).**

- Duties: Conducting focus group discussions, report writing (2019-2020).

Project name**: Potato production support and research to improve food security in Khatlon, Tajikistan – Phase II.** Project owner: International Potato Center (CIP)/University of Central Asia (MSRI)**.** Project funder: **USAID.**

- Duties: Project manager(2017-2019).

Project name**: Ecosystem Services for Poverty Alleviation (ESPA).** Project owner: University of Central Asia/Mountain Societies Research Institute (UCA MSRI)**.** Project funder: **UK AID.**

- Duties: Establishment of an environmental monitoring network, conduct fieldwork in remote rural areas and the development of poverty reduction strategies (2015-2017).

Project name**: Farming Systems and Food Security in mountain areas of Kyrgyzstan.** Project owner: University of Central Asia/Mountain Societies Research Institute (UCA MSRI)**.** Project funder: **UCA.**

- Duties: Main duties: Conduct fieldwork/interviews, the development of academic products (2013-2016).

PEER-REVIEWED RESEARCH ARTICLES:

Azarov A, Maurer MK, Weyerhaeuser H, Darr D. 2019. The impact of uncertainty on smallholder farmers' income in Kyrgyzstan. Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS) **120**: 183–195, doi:10.17170/kobra-20191127816.

Azarov A, Polesny Z, Darr D, Kulikov M, Verner V, Sidle RC. 2022. Classification of Mountain Silvopastoral Farming Systems in Walnut Forests of Kyrgyzstan: Determining Opportunities for Sustainable Livelihoods. Agriculture, **12** (12):2004, https://doi.org/10.3390/agriculture12122004.

OTHER PUBLICATIONS:

Azarov A, Polesny Z, Darr D, Verner V, Sidle RC. Farming systems classification for the assessment of sustainable development pathways in the Tien Shan Mountains of Kyrgyzstan. **Submitted** to Mountain Research and Development.

Azarov A, Polesny Z, Verner V, Darr D. 2020. Characteristics and Profitability of Livestock-based Farming Systems in At-Bashy, Naryn Oblast. MSR's Research paper series (#6). Bishkek. Available from https://ucentralasia.org/publications/2020/april/characteristics-and-profitability-of-livestock-based-farming-systems-in-at-bashy-naryn-oblast (accessed December 2022)

Kulikov M, Shibkov E, **Azarov** A, Isaev E. 2023. Spatio-temporal patterns of different forest type response to climatic factors. **Submitted** to Central Asian Journal of Sustainability and Climate Research**.**

CONFERENCES AND SEMINARS:

Azarov A, Polesny Z, Darr D, Verner V, Sidle CR. 2022. 'Typological characterisation of smallholder silvopastoral farms in the walnut-fruit forests in Kyrgyzstan'. Tropentag 2022: Can agroecological farming feed the world? Farmers' and academia's views. Poster session on Economic Potential of Agroecology. Venue: Prague, Czech Republic.

Azarov A, Kulikov M., Polesny Z., Darr D., Verner V., Sidle C., R., 2022. 'Analysis of livelihood strategies of silvopastoral households in walnut-fruit forests of Kyrgyzstan'. The 8th Annual 'Life in Kyrgyzstan' Conference. Oral session on 'Biodiversity Conservation and Natural Resources' (https://lifeinkyrgyzstan.org/conferences/lik-conference-2022/). Venue: Bishkek, Kyrgyz Republic.

Azarov A, Polesny Z, Darr D, Verner V, Sidle CR. 2021. Typological characterization of livestock-based farming systems to determine sustainable development pathways in Kyrgyzstan. The 7th Annual 'Life in Kyrgyzstan' Conference. Oral session on Agriculture and Climate Change. (https://lifeinkyrgyzstan.org/conference/lik-conference-2021/). Venue: (online).

Azarov A, Foggin M, Kapalova A, Sagynbekova L, Hergarten C. 2017. Empowering agropastoral communities in the Tian-Shan Mountains in Central Asia through citizen science. Citizen Science Association Conference (CitSci2017). Oral session on 'the Power in Traditional Knowledge'. https://csa2017.sched.com/event/ARKK/e-06-the-power-in-traditional-knowledge. Venue: St. Paul, USA.

Azarov A, Maurer M, Weyerhaeuser H. 2016. 'Impact of Kyrgyzstan's accession to the Eurasian Economic Union on the farm income of smallholder farmers in the middle and higher elevation mountain regions. Agricultural Transitions along the Silk Road (IAMO). Oral session on Agricultural Restructuring and Social Impacts https://www.iamo.de/veranstaltungen/agricultural-transitions-along-the-silk-road/presentations/. Venue: Almaty, Kazakhstan.

Azarov A, Dietrich D. 2015. Methodology for mountain farming systems classification. Perth III: Mountains of Our Future Earth. Oral presentation on 'Research for Sustainable Development in Mountain Regions'. https://www.perth.uhi.ac.uk/subject-areas/centre-for-mountain-studies/events/archived-events/perth-iii-mountains-of-our-future-earth/. Venue: Perth, Scotland.

Trainings and seminars

Training course on '**Climate Change and Climate Change Adaptation: Issues in Rural Kyrgyzstan'** (Course organizer: Prof. Roy Sidle, Director, MSRI; Venue: UCA Bishkek, Kyrgyzstan).

- Duties: lecture on section food systems and supply chains (Oct. 2021).

Training course on '**Natural Hazards and Disaster Risk Reduction '.** (Course organizer: Prof. Roy Sidle, Director, MSRI; Venue: UCA Bishkek, Kyrgyzstan).

- Duties: lecture on section food systems and supply chains (Aug. 2019).

INTERNSHIPS:

- Research stays at the Rhine-Waal University of Applied Sciences, Germany (Sept 2019 – Dec 2019).
- Research stays at the Rhine-Waal University of Applied Sciences, Germany (Sept 2015-Dec 2015).
- four-week internship at „Zimmermann Stalltechnik“, Oberessendorf/Germany (Feb. 2010-Mar. 2010).
- Pre-study internship on the farm with dairy cattle and field crop cultivation, Dachsbach/Germany (Apr. 2009- Sept. 2009).

- Study internship at agrarian cooperation " Jeek" with field crop cultivation, Jeek/Kyrgyz Republic (Feb. 2009-Jan. 2009).
- Study internship on "Maiskii" enterprise, Maiskii/Kyrgyz Republic (July 2008-Aug. 2008).
- Internship on the organic farm with dairy cattle and field crop cultivation on the "LOGO e.V", Remptendorf/ Germany (May 2007- Nov. 2007).

AWARDS AND SCHOLARSHIPS:

- DAAD scholarship for education and training in Germany (2019).
- DAAD scholarship for education and training in Germany (2015).
- DAAD scholarship for education in Germany (2009-2011).

ADDITIONAL QUALIFICATION:

Languages:	Kyrgyz:	Native
	Russian:	Native
	German:	Fluent
	English:	Fluent

IT –knowledge: SPSS, MS EXCEL (advanced).