Livelihood and production strategies of smallholder livestock keepers in the Central Peruvian Andes

Master thesis

submitted by

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Summary

The living conditions of smallholder farmers in the Peruvian provinces of Pasco and Daniel Carrión have always been marked by harsh climatic conditions. Crop production is usually not possible over 4000 masl and livestock production guaranteed a frugal livelihood for centuries. But nowadays smallholder farmers in the Peruvian Andes see their livelihoods more and more challenged by environmental and economic changes. Pasture and water quality decline over time and market conditions behave highly volatile. These challenges result in adaptations of their livelihood strategies that can be classified in production strategies and income-generating strategies for further description.

Regarding production strategies, farmers can either diversify and keep several different livestock species or can specify in one or two livestock species. Each strategy brings different advantages and disadvantages. Considering income generation, farmers can earn their income either exclusively from livestock-related activities or also from non-farm activities.

The objective of the study is to investigate income-generating and production strategies of livestock keepers. Further the choice of livestock species in smallholder farmers in the Andean rangelands of Pasco, the farmer’s perception of their own livestock and perceived effects of climate change are investigated.

To address the objective posed above empirical data were taken. Therefore semi-structured interviews were conducted in Spanish language with 46 livestock farmers from the provinces of Pasco and Daniel Carrión and three livestock experts from UNALM. Existing literature in the field was reviewed to gain a deeper understanding of the topic.

The current livelihood strategies can be described as following: Many different species of livestock can be found on the farms in the case study area. These livestock species serve different purposes. As main livestock species alpacas, sheep, llamas and cattle are identified. Most farmers diversify their livestock, as they keep several livestock species in different combinations at once. Only a few farmers can be seen as specialized. These keep mostly alpacas in high numbers, as alpacas guaranteed a good income through the sale of fibre in the last years. A diversified production strategy can be seen as a means to decrease vulnerability regarding environmental and economic shocks and changes. But diversified systems are usually characterized by a low productivity. Also tradition plays a major role, as farmers keep the same livestock species that have been kept on the farm for generations. Specialization as a production strategy seems to be a higher risk and is only undertaken by a few farmers. As the world market for alpaca fibre offered good prices in the last decades, many farmers increased their number of alpacas and declined the number of sheep. Llamas and cattle herds were
found to be rather stable. Especially cattle were identified to offer a reliable daily income to farmers.

The main reasons for a change in the herd compositions were due to economic and environmentally caused reasons as a lack of pasture and declining prices for especially wool.

Climate change is strongly seen as a production constraint by all farmers and the ones that can afford it have already tried to cope via the adoption of diverse adaptation strategies. When asked for future developments in the livestock species composition on their farms, the farmers seem to plan a shift towards a higher number of llamas. Llamas are seen by the farmers to be more resistant to environmental and climatic conditions. But the market for llama products is small and prices are low, so farmers cannot rely on sufficient incomes by only keeping llamas.

Regarding the economic situation of the farmers, more than half of them work in non-farm activities. The range of options to engage in non-farm activities is diverse, as farmers worked in construction, business, transport, as teachers and in other professions. This shows that farmers do not earn sufficient income by livestock husbandry the whole year round and experience a high economic pressure to look for work in other sectors than farm-related ones. Also in the future even more farmers hope to find employment outside their farm. This of course brings changes in the social and cultural context as well, as emigration to urban places or other departments of Peru leads to farm abandonment, what separates the family, as usually women and the elderly are left behind on the farm. Also the farmer’s children seem to prefer other jobs than the ones in animal husbandry. Staying on the farm under harsh environmental conditions does not seem to be very attractive for the young generation.

Therefore investments in infrastructure, better extension services and capacity-building programs should be taken to support farmers to improve their livelihood. This can help to ensure that farmers are offered a perspective for their future in the High Andes.
Zusammenfassung


Als Produktionsstrategien wurden Diversifizierung oder Spezialisierung in der Nutztierhaltung identifiziert. Entweder halten die TierhalterInnen viele verschiedene Nutztierarten zeitgleich, oder sie halten nur ein oder zwei Arten. Jede Strategie bringt unterschiedliche Vor- und Nachteile. Einkommensstrategien betrachtend, können die TierhalterInnen ihr Einkommen entweder ausschließlich aus der Tierhaltung beziehen, oder sie gehen auch nicht-landwirtschaftlichen Tätigkeiten nach.

Das Ziel dieses Forschungsvorhabens war es, die Einkommens- und Produktionsstrategien der TierhalterInnen zu ermitteln. Weiterhin wurden die Gründe für die Auswahl der Nutztierarten und die persönliche Wahrnehmung der TierhalterInnen zu den Vor- und Nachteilen des eigenen Viehbestandes untersucht.

Um sich mit dieser Fragestellung zu befassen, wurden empirische Daten mittels semi-strukturierten Interviews in spanischer Sprache mit 46 TierhalterInnen aus den Provinzen Pasco und Daniel Carrión erhoben. Weiters wurden drei Experten aus dem Bereich Nutztierwissenschaften der UNALM zu ihrer Meinung befragt. Auf bestehende Literatur in diesem Gebiet wurde zurückgegriffen, um ein tieferes Verständnis für das Thema zu gewinnen.


Der Klimawandel wird von allen TierhalterInnen als Gefahr für die Produktion gesehen und die, die die notwendigen finanziellen Ressourcen aufwenden können, haben bereits versucht, sich über diverse Strategien an die geänderten Klimakonditionen anzupassen. Als die TierhalterInnen zu zukünftigen Entwicklungen in der Zusammensetzung der Nutztiere auf ihren Betrieben gefragt wurden, kam heraus, dass die TierhalterInnen planen, in Zukunft mehr Lamas zu halten. Lamas werden von den Bauern als widerstandsfähiger gegen die sich ändernden Umwelt- und Klimabedingungen betrachtet. Der Nachteil hierbei ist, dass der Markt für Lamaprodukte klein ist und die Preise niedrig sind, so dass die TierhalterInnen vermutlich nur durch Lama-Haltung alleine kein ausreichendes Einkommen verdienen werden.

Arbeit zu finden. Ein Leben auf dem elterlichen Hof unter diesen schwierigen Bedingungen scheint für die junge Generation nicht sehr attraktiv zu sein.

Unter anderem sollen Investitionen in Infrastruktur getätigt werden und bessere Ausbildungsmöglichkeiten angeboten werden, damit die TierhalterInnen auf ihren Höfen bleiben können. Dies kann ihnen eine Zukunftsperspektive im ländlichen Gebiet der Anden geben.
Résumen

Las condiciones de vida de los pequeños criadores de ganado de las provincias peruanas de Pasco y Daniel Carrión siempre se han caracterizado por las duras condiciones climáticas. La producción de cultivos, por lo general, no es posible a más de 4000 msnm y la ganadería ha garantizado un sustento frugal durante siglos. Hoy en día, los pequeños criadores en los Andes peruanos ven sus medios de vida cada vez más cuestionada por los cambios ambientales y económicos. La calidad del pasto y del agua ha disminuido y las condiciones en el mercado se comportan de una manera muy inestable. Estos desafíos en conjunto, han generado cambios en las estrategias de medios de vida que se pueden clasificar en las estrategias de producción y las estrategias de generación de ingresos.

En las estrategias de producción, los agricultores pueden diversificar y mantener varias especies de ganado o pueden especializarse en una o dos especies de ganado. Cada estrategia trae diferentes ventajas y desventajas. Teniendo en cuenta la generación de ingresos, los agricultores pueden obtenerlos, ya sea exclusivamente de las actividades relacionadas con la ganadería o también de las actividades no agrícolas.

El objetivo del estudio es determinar las estrategias de generación de ingresos y la producción de los ganaderos. Además, se investiga la selección de las especies ganaderas de los pequeños agricultores en los pastizales andinos de Pasco, la percepción de los agricultores de su propio ganado y efectos percibidos del cambio climático.

Para contestar el objetivo planteado, se utilizaron datos empíricos. Para lo cual, se realizaron entrevistas semi -estructuradas en lengua española con 46 ganaderos de las provincias de Pasco y Daniel Carrión y tres expertos de ganado de la UNALM. La literatura existente en campo fue revisada, con la finalidad de obtener una comprensión más profunda del tema. Las estrategias de los medios de vida actuales se describieron de la siguiente manera: Muchas especies diferentes de animales se pueden encontrar en granjas de las zonas investigadas, estas especies de animales se usan con diferentes objetivos. Como especies principales de ganado se identificaron: alpacas, ovinos, llamas y vacunos. La mayoría de los agricultores diversificaban su ganado, manteniéndose varias especies de ganado en diferentes combinaciones a la vez, solo unos pocos agricultores pudieron ser clasificados como especializados. Éstos mantienen principalmente alpacas en grandes cantidades, ya que ellas garantizan un buen ingreso económico a través de la venta de su fibra. La estrategia de diversificación de la producción puede ser vista como un medio para disminuir la vulnerabilidad en relación con las crisis ambientales, económicas y los cambios. Pero los sistemas diversificados tienen como característica una baja productividad. La tradición, también juega un papel importante, ya que los agricultores mantienen las mismas especies de ganado durante generaciones.
especialización como estrategia de producción, pareció ser de mayor riesgo y sólo era llevada a cabo por unos pocos agricultores. A medida que el mercado mundial de la fibra de alpaca ha ofrecido buenos precios en las últimas décadas, muchos agricultores han aumentado su número de alpacas y disminuido el número de ovejas. Los números de llamas y vacunos en los rebaños parecen bastante estables. El vacuno especialmente, ofrece una renta diaria fiable a los agricultores. Las principales razones que pudieron generar un cambio en la composición del rebaño se debieron a razones económicas y del medio ambiente, causadas como la falta de pastos y la disminución de los precios de la lana en especial.

El cambio climático está visto como una limitación de producción por todos los agricultores y a los que se les ha permitido económicamente, han tratado de hacer frente a través de la adopción de diversas estrategias de adaptación. Preguntando por la futura evolución de la composición de las especies de animales en sus granjas, los agricultores parecen planear un cambio hacia un mayor número de llamas. Las llamas son vistas por los agricultores como más resistentes a las condiciones ambientales y climáticas. Sin embargo el mercado de productos relacionados con las llamas es pequeño y los precios son bajos, por lo que los agricultores no pueden ganar ingresos suficientes solo criando llamas.

En cuanto a la situación económica de los criadores, más de la mitad de ellos trabajan en actividades no ganaderas. La gama de opciones para realizar actividades no ganaderas es diversa, ya que los agricultores trabajan en construcción, negocios, transporte, como maestros y en otras profesiones. Esto demuestra que los criadores no obtienen ingresos suficientes procedentes de la cría de animales durante todo el año, y experimentan una alta presión económica para buscar trabajo en otros sectores que en los relacionadas con la ganadería. También en el futuro aún más agricultores esperan encontrar empleo fuera de su granja. Por supuesto, esto trae consigo cambios en el contexto social y cultural, así como la emigración a zonas urbanas o en otros departamentos del Perú que llevan al abandono del campo, separando a la familia, ya que por lo general las mujeres y los ancianos se quedan atrás en la granja. También los hijos de los ganaderos parecen preferir otros puestos de trabajo que el de la cría de animales. Permanecer en la granja bajo estas duras condiciones ambientales no parece ser muy atractivo para las nuevas generaciones.

Por lo tanto el gobierno y la sociedad peruana en su conjunto deben reaccionar y ofrecer perspectivas para el futuro a los criadores. Inversiones en infraestructura, mejores programas de extensión y capacitación deben ser tomadas para que los agricultores se queden en sus granjas y continúen con sus estrategias tradicionales de producción de animales.
1. Introduction

Worldwide, smallholder farmers face increasing threats to their livelihoods. Livestock farmers of the Peruvian central Andes are no exception. These threats are mainly market- and climate change related. Livestock farmers have developed different livelihood strategies to secure their household income and food security. These strategies include production- and income-generating activities.

Possible production strategies within the livestock sector are specialization of one species or a few different species, or diversification of livestock. The study region Cerro de Pasco (Peruvian Central Andes) is known for meat and milk production and the main livestock species are llamas, alpacas and sheep (Wurzinger et al. 2013). They are mostly raised by smallholder farmers who consider them as essential assets for their livelihoods (Gutierrez 2013). The choice of domestic species for production based on the species’ advantages and disadvantages has been a subject of controversy for a long time in the Andean highlands (Tichit & Genin 1997). Therefore it is necessary to determine the main factors influencing the choice of production strategies in smallholder farmers in the Andean rangelands of Pasco considering their perception of their own livestock.

Within the whole economic sector possible strategies are alternative income generation by crop agriculture or non-farm economical activities. Non-farm economical activities comprise employment in transport, construction, commerce and mining among others. These different strategies imply advantages and disadvantages for the farmer, which will be also further investigated in this research. Non-farm activities might be of an increasing importance in the region, mostly due to an increase in the mining industry. The contribution of non-farm income to rural households and the distribution of benefits from non-farm employment across the populations is still not completely understood (Deininger 2001). The decision of which strategy to choose, on-farm or non-farm, could be influenced by several factors such as education, household size, location, consequences of climate change and others.

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1 There is no general definition of “smallholder farming”, as there are many options depending on different contexts and levels. “Usually it is practised by families (including one or more households) using only or mostly family labour and deriving from that work a large but variable share of their income, in kind or in cash […] A smallholding is “small” because resources are scarce, especially land, and using it to generate a level of income that helps fulfil basic needs and achieve a sustainable livelihood consequently require a high level of total factor productivity, requiring in turn a significant level of investment” (HLPE 2013).

2 Livelihood is here defined and used as the combination of the household and production system, and includes socio-cultural values of the household (Aklilu et al. 2007).

3 Highlands are defined as those areas which are above 1500 meters above sea level (Gebremedhin et al. 2004).
Therefore the main objective of this thesis is to explore the present and future livelihood strategies of livestock farmers in the Peruvian Central Andes facing multiple stressors of economic and physical nature.

As already mentioned, a factor that could influence the selection of a specific production strategy is the effect of climate change. According to IPCC (2007), Peru is already being affected by a changing climate. Therefore the second objective of this study is to assess the consequences of climate change on animal husbandry in the Pasco region and its influence on farmer’s livelihood decisions.

2 Literature review

2.1 Introduction to Peru and its ecological background

2.1.1 Location and ecosystems

Peru is located on the western side of central South America. Its borders are the Pacific Ocean to the west, Ecuador and Colombia to the north, Brazil to the east and Bolivia and Chile to the south. The population is about 29 million people and the total area is 1 285 216 km². It is divided into three natural regions: the coast with an area of approximately 11% of the country, the sierra (the mountains) including the Andes mountain range and accounting for 27% of the country’s land area, and the selva (the jungle) which covers 62% of the country. The biggest part, about 60%, of the population lives in the coastal area and fewer people in the sierra and selva (INEI 2013).

The Andean region has several eco-regions with different climatic, cultural and socio-economic features (Genin & Alzérreca 2006). The Central Andes are a high mountain ecosystem in an altitude of more than 3000 m (Rodríguez & Quispe 2007) with large areas of native pastures being used as a grazing system, covering about 20 000 ha in Peru (Dudal 1980). The main plant communities are pajonales (low-quality grasses for ruminants), cesped de puna and bofedales (Novoa & Florez 1991).

The sloping mountain ecosystems are susceptible to changes and loss of its ability to keep a sustainable crop-livestock production. Consequently, the major problem of the Andean region is soil erosion, caused by natural losses and the intervention of the humans with inadequate agricultural and livestock practices (Leon-Velarde et al. 2000). Soils in this region are mostly inceptisols and mollisols (Sánchez & Tergas 1979). Others in lower occurrences are regosols, andosols, cambisols, calcisols, vertisols and kastanozems. Low levels of phosphorus and nitrogen are common. Less than 3 percent of the land in the Andes is suitable for crop production, highlighting the importance of animal production. Main soil-linked risks are increasing erosion and desertification (INRENA, 1996, as quoted in Flores et al. 2007).
2.1.2 Climate and climate change

Peru is one of the most climatically diverse countries in the world with 27 out of 32 different climates (MINAM 2013). Peru has more fresh water per capita than any other South American country (Olson 2006), which it is unequally distributed between the different ecological areas (Eda & Chen 2010; Lynch 2012). Therefore, climate change is expected to have a big impact on the country’s ecology and economy.

According to the Intergovernmental Panel on Climate Change (IPCC 2007) and the ministry of environment (MINAM 2013), significant increases in precipitation were observed in north-west Peru and a declining trend in precipitation was observed in southern Peru during the 20th century.

Mountains are among the regions most sensitive to climate change. Some of the most visible indicators of climate change come from mountain areas, such as the widespread retreat of glaciers (Kohler & Maselli 2009). Juen et al. (2007) and IPCC (2007) argue that in the Peruvian Andes glacier melt is changing and the runoff seasonality is amplified. During the wet season, when runoff is already high, glacier melt runoff increases. Dry season runoff, which is mainly dominated by glacier melt, will be reduced. This decrease of an already low runoff together with a fluctuating annual precipitation will challenge future water management considerably, as about 10 million residents of Lima depend on freshwater from the Andes.

Essentially the mountainous sierra is going to get dryer (Torres & Gómez 2008). In the region of Cerro de Pasco, according to the National Service of Meteorology and Hydrology (SENAMHI), the annual precipitation was declining in the last decade and seems to have reached a stable level of 900mm a year. Still, fluctuations in precipitation are expected to be stronger and grasslands might dry out quicker (Plasencia, s.a.). This might make farmers move their animals rapidly in search of more favourable conditions (FAO 2001). Apart from water scarcity and scarcity in forage quality and quantity, other common negative effects that are possible to occur are lower animal production due to changed air temperatures, which could be higher (leading to heat stress) or lower (leading to a higher susceptibility of some diseases) on average. The intensity and distribution of diseases and parasites is also expected be influenced by climate change, adding new challenges to livestock rearing (Fox et al. 2012; Thorton et al. 2009 and references therein).

To conclude, the scientific community agrees that climate change is happening and will continue into the future regardless of the effectiveness of mitigation measures (Christensen et al. 2007, as quoted in Mertz et al. 2009b) This means that the livelihood of millions of people in the Andes will be negatively affected, as changes in climatic conditions jeopardize agricultural production and animal husbandry (Torres & Gómez 2008). Farmers in poor countries will even have to adapt to climate
change to an extent which might be beyond their adaptive capacity because of the level of poverty and therefore lack of resources found in many regions (Mertz et al. 2009a). This displays the need to understand how farmers in the high Andes cope with climate variability and change in order to guide the strategies for adaptation in the future (Mertz et al. 2009b), as farmers’ ability to perceive climate change is a key pre-condition for their adaptation choice. Without adaptation, climate change’s consequences would have detrimental influences on the livestock and agricultural sector, and with adaptation, vulnerability can be significantly reduced and mitigated (Gbetibouo 2009).

2.1.3 Living conditions of rural communities in the Peruvian context
Considering the growing Peruvian economy in the last decade (Wiig 2013), it might be paradox that poverty is still a worrisome issue in Peru. According to government statistics, less than a third of the Peruvian population nowadays lives below the national poverty line, compared with around half of the population in the early 2000s. Nevertheless, about 8 million Peruvians remain poor, and poverty is deepest among people of Quechua and Aymara origin living in remote rural areas (IFAD 2013). Almost half of the 1.7 million people considered „extreme poor“ live in the arid Andean highland areas. Food insecurity is chronic in rural regions, where many smallholder farmers produce basic food crops at a subsistence level or depend mostly on animal husbandry for their livelihood, and where daily life is still a struggle to survive (Kristjanson et al. 2007).

Regarding poverty, women are the worst affected. Most rural women are regarded as poor or extremely poor, even as they play a central role in the subsistence agricultural economy and in livestock keeping. According to Jamtgaard 1989, as cited in Burfening & Chavez (1996), women and children are in charge of grazing and moving the animals daily, and have responsibility for the flocks and small animals raised at home.

Women therefore engage in income-generation, mostly on-farm, representing up to 80 per cent of a family’s labour force. Through these productive activities – along with traditional household tasks and child care – women make it possible for their husbands to migrate in search of temporary work (Budak et al. 2005; IFAD 2013).

The emigration from the Andean highlands because of a lack of opportunities for rural people gives ample evidence that residents view life chances elsewhere more favourable and expect a better life in urban areas (Swinton & Quiroz 2003). People migrate to urban centres, mainly to the capital city Lima, where market activity offers better livelihood options. Today, three out of four Peruvians live in and around urban areas (IFAD 2013). This leads to abandonment of farms, villages, agriculture and livestock. Another reason for farm abandonment is the higher salary being paid in mining companies,
as mostly young male farmers prefer to work in mines and thus leave animal husbandry temporarily or permanently (Flores 2013).

Reasons for poverty in rural communities are manifold. According to Webb (2013) geographical isolation and dispersion of the population has been a significant cause of persistent rural poverty in Peru, complicating market access. Another constraint rural communities have to face at high elevations is the unstable environment. Water availability is more likely to fluctuate due to climate change and competition for water is intensifying (Lynch 2012). It especially has to be considered that households in these regions already have to cope with extreme climate and environmental challenges, including altitudes up to 5000 m, intense solar radiation, low levels of atmospheric oxygen, low average annual temperatures, limited vegetation coverage and poor forage for their livestock. Due to frequent frosts throughout the year people face major obstacles to crop cultivation, so livestock is often the farmer’s only resource for food security, clothing and extra income (Flores et al. 2007; Kristjanson et al. 2007; Sumar & Camino 1992). Farmers living in areas with difficult environmental conditions have to keep animals that are well adapted to their surrounding environment. Consequently continuous improvements of genotypes, livestock breeds and species are needed (Mirkena et al. 2010). Also Kristjanson et al. (2007) point out in their paper that improvements in livestock quality (via intensification strategies or increasing productivity and marketing, rather than through increased herd sizes) and livestock diversification might help to alleviate poverty. Households that were able to improve the quality of their livestock were much more likely to escape from poverty to some extent as those that were unable to invest in this strategy.

2.2 Livestock production in the Andean highlands of Peru

Alary et al. (2011) and Birner (1999) state that theories of economic development commonly do not recognise the importance of livestock farming to alleviate poverty in the farming sector. But livestock farming fulfils a variety of functions that must not be neglected. Recognizing its unique features is crucial to improve the living conditions of livestock farmers. For example, crises affect livestock farmers in ways that are almost directly opposite to the ways in which they affect crop farmers. When climatic factors reduce crop yields, market prices increase because of the increasing value of grains. When the same factors affect the herders' ability to keep livestock alive, prices fall because of competition with other livestock owners who are also attempting to sell animals (FAO 2001).

Delgado (1999) argues that poor and landless people derive a higher proportion of household income from livestock sources than those with greater wealth living in the same communities do. Therefore primarily in developing countries with earlier phases of socio-economic development,
Small ruminants (sheep) or pseudo-ruminants (as camelids are considered to be⁴) are valuable to resource-poor farmers, as they can make a contribution to improve farmer’s livelihoods (Alary et al. 2011; Alvear 2007). These contributions range from animal proteins (meat and milk being in some cases the main protein source) to fibres, wool and hides, usage of manure as fuel and fertilizer, draught power, use as pack animals, as a form of capital accumulation and insurance and better food security (Markemann et al. 2009). Improvement of livestock farming is constrained by inefficient use of properly adapted breeds, inefficient and inappropriate production systems, poor strategies for improved natural resource management, and inadequate official support and resource use (Devendra 2007; Jahnke 1983, as cited in Birner 1999; Udo et al. 2011). According to Alary et al. (2011), there are difficulties in measuring the contributions of the small ruminants sector towards economic development, which affects negatively the directions of political and economic policy decisions towards a sustainable development of these activities. In addition, the choice of what livestock species to keep and what feeding system to use (pasture-based, purchased concentrate-based, or mixed) can impact significantly the sustainability of a farm in terms of environmental performance, and the water and pasture resources needed (Bartl et al. 2011).

Oltjen and Beckett (1996) have also confirmed the importance of ruminant livestock in creating sustainable agricultural systems:” Cattle, sheep, and goats are particularly useful in converting vast renewable resources from rangeland, pasture, and crop residues or other by-products into food edible for humans. With ruminants, land that is too poor or too eroded to be cultivated becomes productive” (Oltjen and Beckett 1996).

Crop-livestock systems vary considerably in their extension and importance across the different agro-ecological zones of Peru, as a result of differences in water availability, altitude, risk of frost, slope, and access to markets and market demands (Table 1, Leon-Velarde et al. 2000).

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⁴ SACs are not true ruminants, but are seen as pseudo-ruminants by various authors (Dekker et al. 2013; Mackie et al. 1997, as cited in Turnbull et al. 2012; Osman et al. 1981).
In the high Andes, as unstable climate with many episodes of frost do not favour crop farming, livestock husbandry is crucial to the poorest Peruvian rural households (Anderson 2003; Trejo 2004). Common livestock are cattle, sheep, goats, South American Camels (SACs), pigs, guinea pigs, rabbits, mules, donkeys, horses, ducks and chickens, showing a big variety of animal resources with specific functions within the system. Sheep, goats, SACs, pigs, mules, donkeys and horses are usually kept in herds, also used as work force, whereas guinea pigs, chickens, ducks and rabbits are kept inside or around the family houses (Fernandez et al. 1986, as quoted in Burfening & Chavez 1996). Surprisingly, meat consumption is quite low, and livestock is rather seen as an income source and a financial security (Flores & Bryant 1989). Livestock production in the highlands of Peru is largely based on small ruminant and pseudo-ruminant species grazing on natural pasture, sometimes supplemented with crop residues, or agricultural by-products and, in rare cases, with improved feed resources. Thus rangelands, with native grass species, constitute the main feed resource for mixed crop-livestock systems with small ruminant species. Livestock productivity is affected by low nutrition, parasitism or infectious diseases, as well as the lack of an adequate breeding selection (Leon-Velarde et al. 2000).

### Table 1. Crop-livestock systems

<table>
<thead>
<tr>
<th>Agro-ecological zone</th>
<th>Altitude (m)</th>
<th>Rainfall (mm)</th>
<th>Livestock/Crops</th>
<th>Main livestock products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-andean valleys</td>
<td>200-2700</td>
<td>250-700</td>
<td>Cattle, maize, beans, alfalfa, ryegrass</td>
<td>Milk, cheese</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cattle, sheep, goats, wheat, barley, maize, root and tuber crops</td>
<td>Milk, cheese, wool, dung</td>
</tr>
<tr>
<td>Hillsides</td>
<td>2700-3500</td>
<td></td>
<td>SACs, sheep, cattle, oats, potatoes, barley, quinoa</td>
<td>Milk, cheese, wool, fibre, dung</td>
</tr>
<tr>
<td>Suni/Jaica</td>
<td>3400-4000</td>
<td>500-1300</td>
<td>SACs, sheep, cattle, oats, bitter potatoes, quinoa</td>
<td>Milk, cheese, wool, fibre, dung</td>
</tr>
<tr>
<td>Puna</td>
<td>3800-4500</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: modified after Leon-Velarde et al. 2000
Considering that cattle bring a bigger share to the farmer’s income, they usually graze on the best, sometimes cultivated pastures and SACs are kept on poorer pastures (Naupari, personal communication).

The total surface of Andean highland natural pastures is estimated to be about 20 million ha (Ohern, 1980). These grasslands support 82% of the livestock production of Peru. Thus considering their importance for the economy of the country it is necessary to study and understand all environmental factors that affect productivity and conservation of this vast natural resource (Rodriguez et al. 1986).

In the central Andes region three grassland types can be found:

1. **Pajonales**: Pajonales are characterized by the predominance of grasses (*Graminaceas*) as the main forage species, covering an approximate area of 18 million hectares. The most representative genera are *Festuca, Stipa, Poa and Calamagrostis* that have physiological adaptations to the dry and cold conditions of the Andean highlands, such as the presence of needle-like leaves that reduce evaporation and transpiration (Novoa & Florez 1991).

2. **Cesped de Puna**: This pasture type can be found above 3800m with an extension of about 14 million hectares and is characterized by low vegetation rhizomatous plants that occupy flat land with moderately moist stony soil. This area cannot be used for agricultural production anymore (Flores & Bryant 1989). *Graminacea* are the predominant species, other species are flat and cover the soil, other common plants are characterized by rosette leaves. The most common plant families are *Aciachne* and *Calamagrostis* associated with other grasses such as *Agrostis, Festuca* and *Asteraceae* (Flores et al. 2005).

3. **Bofedales**: Bofedales are high-altitude wetlands with permanent moisture originating from rainfall, melting glaciers and groundwater where the soil drainage is insufficient. These wetlands are formed in Andean plateaus located about 3800 meters and are usually close to lakes. Plant associations are *Juncaceas* and *Cyperaceas*, with *Distichia* and *Plantago* being dominant plant species. The soils are organic or peat soils with various meters of profundity. *Bofedales* play a crucial role especially during the dry season as a food reserve and are the preferred vegetation type of alpacas (Flores et al. 2007; Novoa & Florez 1991).

Peru is the most important center of SACs in the world considering the number of individuals. The traditional subsistence system in the Andes is highly based on diversification of resource exploitation in order to minimize risks and assure their survival in the harsh mountainous climate. Over 4000m above sea level crop agriculture is very limited due to climatic variability and main crops are potatoes, oats, and some other root plants. As SACs usually graze above these limits, they do not
compete for land for crop production, as opposed to cattle. This means that SACs and to some extent sheep are the most reliable nutritional and economic sources for the communities.

2.2.1 Description of South American camelids (SACs)

The South American camelids (SACs) include two wild species (that are not of further interest in this master thesis), the guanaco (*Lama guanicoe*) and the vicuna (*Vicusna vicugna*), as well as two domestic species, the llama (*Lama glama*), which originates from the guanaco, and the alpaca (*Vicusna pacos*), which is thought to originate from the vicuna (Kadwell et al. 2001). Then there are intermediate types called "Huarizo", being a cross-breed of a male llama and a female alpaca, or “Misti”, of a female llama and a male alpaca. Both of them are fertile (Alhadrami et al. 2004; Briones & Valdivia 1985).

SACs are classified together with the Old World camels (African dromedars, *Camelus dromedarius* and bactrian camels, *Camelus bactrianus*) in the order *Artiodactyla* (even-toed ungulates), suborder Tylopoda (pad-footed), and family Camelidae. Ruminant digestion of camelids evolved independently of, and parallel to, ruminant digestion in the suborder Pecora, explaining the anatomical differences of their stomachs (Alhadrami et al. 2004; Bohlken 1960, as quoted in Wheeler 1995).

At present, more than one million llamas and three million alpacas are reared by Andean herders in Peru with very limited resources on high elevation pastures (Fernández-Baca 2005). SACs also live traditionally in Chile, Bolivia, Ecuador and Argentina, but since the last decades they can be found outside of South America as well (Sumar & Camino 1992).

Breeding alpacas and llamas in Peru takes place mostly in the Andean region of the southern and central *sierra* at altitudes ranging from 3800m (or less) to 5000m. Between 3800m and 4000m altitude, husbandry of alpacas and llamas is usually combined with other livestock species and agricultural activity, but above 4000m mainly SACs, alpacas in particular, are kept (Fernández-Baca 2005).

In general, llamas are raised for use as pack animals and for meat production, while alpacas are bred for fibre production. Cross-breeding between them occurs (Wheeler et al 1995).

No use of milk products have been reported from SACs, as they have historically not been bred for dairy purposes. Some authors though see a potential for SACs as milk producers, saying that these milks are an underestimated nutritional and economic resource for the people living in the Andes (Fernandez and Oliver 1988 and Riek and Gerken 2006, as cited in Muehlhoff et al. 2013; Leyva et al. 1985 and Ochoa 1985, as cited in Farfan et al. 1989).
SACs played a crucial role in the development of human civilizations in the South American continent, as they were used traditionally as an energy source for transport and meat production (Flores Ochoa 1977; Sumar & Camino 1992). After the Spanish arrived in the 16th century, American SACs were seen as inferior to European livestock, called “animals of the poor” or “animals of the Indians”. Their husbandry was discouraged (Claros Goitia et al. 1999) and resistance to the consumption of llama meat by parts of the (urban) society came up and is still prevalent (Markemann et al. 2009). Livestock brought by Europeans were accepted by the native farmers as new resources (Sumar & Camino 1992). In the end only 10% of the existing SACs herd number survived (Flores Ochoa 1977) and a lot of genetic diversity, breeding strategies and local knowledge got lost (Wheeler 1995).

The anatomical characteristics of SACs are shortly explained here: As a difference to true ruminants, SACs do not have horns, but do have true canine teeth, separated from the premolars. From the standpoint of the gastrointestinal anatomy they had an independent evolution of the so-called true ruminant suborder Pecora considering their three stomach compartments with respect to cows and other true ruminants that have four. Nonetheless they use similar mechanisms in their digestion (Lamo 2011) bearing in mind that they have an expanded foregut to facilitate microbial fermentation of ingested feedstuffs and they chew their cud (Van Saun, s.a.). This is why SACs are also called pseudo-ruminants, as already highlighted before (Dekker et al. 2013; Mackie et al. 1997, as cited in Turnbull et al. 2012; Osman et al. 1981). SACs are capable of an improved fermentation of ingested feed material compared to true ruminants as a result of prolonged feed retention time. This digestive approach would facilitate a diet composed mostly of highly mature, poorer quality forages. In their natural environment, SACs consume this type of diet. From another perspective, high quality forages like alfalfa may result in excessive fat accumulation when fed to SACs (Van Saun, s.a.).

SACs have a gestation length of 11.5 months and give birth to only one off-spring per birth (Lamo 2011). Twins or multiple births are not known.

Both llamas and alpacas also play a major role in culture and tradition of the Andean cultures (Flores Ochoa 1977). But because of expansion of road systems llamas are less needed as pack animals, so llama population is declining (Camino 2002). But alpaca fibre production is increasing over the last years (FAO 2001).
2.2.2 SACs and sheep in the Peruvian Andes

2.2.2.1 Llama

The llama (Lama glama) is the largest American camel and can reach an adult weight of 120 kg and can be as tall as 2m (head). It is kept primarily as a supply of meat and for transportation, but one type also produces fibre (but generally of a lower quality than the alpaca and in smaller amounts). Two different types exist, the K’ara and Chaku (can also be spelled differently, in Spanish they are called Pelada and Lanuda) which differ in body sizes and fibre quantity and quality (Fernández-Baca 2005). The type called K’ara develops less fibre, especially on the legs and the throat, and does not have any fibre in the face. The colour varies from white to black, and sometimes colour shades identical to the guanaco can be found. This animal has been selected rather for meat production. In Peru the most important breeding areas are in the departments of Pasco and Junín. The other type, Chaku, has more fibre. Its colour varies from white to brown to black (Lamo 2011).

The distribution of llamas extends along the Andes from southern Colombia to central Chile (Lamo 2011). The largest number of llamas in Peru can be found in the provinces of Puno, Cuzco, Huancavelica and Junín (Fernández-Baca 2005) and the population size of llamas in Peru is about 1.2 million individuals (MINAG 2010).

Figure 1: Llamas on a farm in Pasco department

Llamas play a crucial role in the subsistence of smallholder’s livelihoods in the Andean regions, fulfilling various functions in the productive, social and cultural life of the people. The llama population had been decimated with the Spanish invasion, which resulted in a drastic decline of their
regional distribution. They survived within the framework of a traditional, socioeconomic context and continue to be one of the most reliable nutritional and economic resources available to the peasants who inhabit zones at, or above, the upper limit of crop cultivation (Markemann et al. 2009).

Llamas usually graze on poor pastures in dry altitudes that are not being used for ruminants (Naupari, personal communication), but Markemann et al. (2009) argues that they as well might be in competition with ruminants or crop production. Llamas may be better adapted than alpacas and sheep to subsist on coarse forage in drier Andean regions as a consequence of their foraging behaviour (Munoz 1993; Pfister et al. 1989). Also Sponheimer et al. (2002) suggest that llamas perform better on low-quality forages than alpacas due to a higher dry matter digestibility relative to metabolic weight. Food passage in their stomach is slower than for other ruminants, so they can better use and digest their food (San Martin and Bryant 1989).

2.2.2.2 Alpaca

The alpaca (Vicugna pacos), has the largest distribution in Peru considering individual numbers and it is mainly kept for fibre production. The population has been growing in the last decades reaching a number of more than 3.5 million individuals in 2012, with the biggest population number being in Cusco and Puno (INEI 2012).

There are two different types of alpacas: Huacaya and Suri, which clearly differ by their phenotypic characteristics. Suri alpaca fibres are longer and are arranged in curls falling over the sides of the body, similar to what is observed in some sheep breeds. As their back is uncovered with fibre, Suris are said to be more susceptible to cold temperatures and get pneumonia easily, so this is why farmers prefer to keep them in low altitudes. Suris only form about 12.2% of the whole Alpaca population. The Huacaya (80.2%) variety has different, shorter fibre, similar to the wool of the sheep breed Corriedale, which gives it a more voluminous look and a “spongy” appearance. Then there is a mixture between these two types called Cruzado that represent about 7% of the population (Fernández-Baca 2005; INEI 2012).
Apart from fibre production the alpaca is also used for meat due to its high nutritious content, and hides are also used mainly in handicraft production (Fernández-Baca 2005).

One of the main problems in alpaca production is a high embryonic mortality leading to a natality as low as 50% due to nutritional deficiencies (Reiner & Bryant 1986).

2.2.2.3 Sheep

Domestic sheep (Ovis aries) are relatively small ruminants and grazing herbivores. They are kept for their wool, meat and manure, and the introduction of sheep for milk production is also being promoted in more favourable areas of Peru (Oré Meza 2012). Sheep are not native to Peru as they were introduced by Europeans, but got accepted by the native farmers as new livestock resources, probably due to political measures favouring sheep over native camelids (Martinez 1985, as quoted in Burfening & Chavez 1996). Sheep adapted well to the environmental condition in the Andes, but show a lower productivity at high altitudes (Sumar & Camino 1992). They are said to not compete for pasture with SACs by some authors (Sánchez Reyes 2003) as they feed on herbs and “soft grasses” (Genin et al. 1994, as quoted in Alvear 2007), while others argue that they do compete with alpacas (Flores 2013; Pfister et al. 1989).

In Peru there are a bit more than 9 million sheep, and more than 90% of this population is located in farmer communities in the sierra (Burfening & Chavez 1996; INEI 2012). These sheep produce about 31 000 t of meat and 13 000 tons of wool, generating income for the livelihood of more than 1 250 000 rural households (Diáz Ramirez 2007). Sheep are raised mostly in the Andean highlands at 3500m above sea level or higher (Burfening & Carpio 1995), feeding on natural pasture that grows in land...
unsuitable for agriculture and bovine livestock production (Burfening & Chavez 1996). The regions with highest sheep populations are Puno, Cusco and Junín (Diáz Ramirez 2007).

About 80% of Peruvian sheep are crossbreeds called Creole or Criollo. This type originates from various breeds from the Iberian Peninsula that were introduced to America several centuries ago and have adapted to different ecological characteristics. The Criollo is known for hardiness, a lower degree of breeding seasonality and for being an efficient grazer (Fernández-Baca 2005). They usually occur in the highlands of the Andes at 3 500m above sea level (Burfening & Chavez 1996). Other breeds that can be found in Peru are Corriedale, Hampshire Down, Black Belly, Junín (a locally developed breed) and Merino (Burfening & Chavez 1996; Diáz Ramirez 2007; INEI 2012).

Economically sheep are the most important livestock in the Andes (Flores et al. 2007). Diáz Ramirez (2007) argued that the trend of the sheep population and the production of wool and meat is slightly increasing, despite the declining price of wool and meat at the producer level, insufficient technical assistance, rural depopulation, low technology and overgrazing. But according to INEI (2012) the numbers of sheep have declined from 1961 from more than 23 million sheep to 9.5 million sheep in 2012, primarily in the provinces of Puno and Junín.

Another important product of sheep is their manure, which is highly valued as a fertilizer and cooking fuel. Sheep serve as gatherers of nutrients from distant and less productive areas and concentrate them on farmer’s land, increasing the land production potential (Jamtgaard 1989, as quoted in Burfening & Chavez 1996).

2.2.3 Adaptation to Andean environment

Ruminants can generally be found in diverse and extreme climates. Their digestion system’s anatomy and physiology is adapted to different feed resources and via microbial fermentation in their fore stomachs they can use cellulosic material for their nutrition (Alvear 2007). Both sheep and SACs possess a multi-compartmented stomach, with sheep as classical ruminants having four different compartments and SACs having three (as discussed above).

Some researchers argued that domestic SACs have advantages over ruminants (here sheep) due to their adaptation to the Andean highland environment and their more efficient use of natural resources as vegetation and soil (Lewis 1976; Silanikove 1987, as quoted in Silanikove 2000; Sumar & Camino 1992; Rodriguez & Quispe 2007), while others argue that sheep have a higher productivity rate than SACs because of their higher fertility rate and a better market for their products (Tichit et al. 2004). However, mixed herds of both SACs and sheep are most commonly seen in the Andean rangeland systems (Flores et al. 2007; Genin & Alzérreca 2006; Tichit & Genin 1997). The decision-
influencing factors might depend on the farmer’s family structure, their level of wealth and non-farm incomes (Tichit & Genin 1997).

SACs as being native to the Andean region are physically and physiologically adapted to the harsh environmental conditions by a range of unique adaptive traits (Rodríguez & Quispe 2007). Adaptation means here, that the animal has the ability to survive and reproduce within a defined environment (Prayaga and Henshall, 2005, as quoted in Mirkena et al. 2010).

Some of the adaptations and advantages of SACs are listed here:

- SACs are protected against altitude sickness that strikes many introduced livestock species (Branchero et al., 1971; Sillao et al., 1972, as quoted in Rodríguez & Quispe 2007) by obtaining their oxygen from low pressure environments (Meschia et al. 1960; Sumar & Camino 1992), due to higher blood O\textsubscript{2} affinity (Roy 2007), the high level of haemoglobin and the elliptical shape of their red blood cells (Lewis 1976).

- SACs can survive on scarcely-available and low-quality feed resources and digest grasses high in lignin (Genin & Tichit 1997; Rodríguez & Quispe 2007; Sumar & Camino 1992). Flores & Gutierrez (1995) found that SACs chew and digest long forages more efficient than sheep, but this could not be proven by a study realized by Sponheimer et al. (2002).

- Their grazing behaviour does not have a degrading effect on the Andean grasslands since SACs bite off their forage (Sumar & Camino 1992; Wheeler 1982, as quoted in Rodríguez & Quispe 2007). SACs have split upper lips that are mobile and help them to select leaves from hard plant parts and with their sharp incisors they cut short and lignin-rich forages without harming the whole plant (Sumar & Camino 1992).

- Silanikove (1987, as quoted in Silanikove 2000) and San Martin and Bryant (1989) report a reduced energy metabolism in times of low energy intake. Retention time of digested food is higher in SACs than in sheep, and the liquid passage rate is lower. Protein and energy requirements are lower, as SACs are surviving on coarse native grasses, sedges and rushes. They also thrive at places with a very low content of copper and phosphorus in the soils, where cattle and sheep show deficiency diseases.

- Another advantage is the chewing time of the herbage by SACs, as they chew their feed longer than sheep (Vasquez 1997). SACs also chew and ingest longer forage more efficiently than sheep (Flores & Gutierrez 1995).
• Mendoza (1991) showed that SACs are more water efficient than sheep as they drink less per body size and handle better droughts and other water scarcities.

• SACs show a high resistance to cold weather and handle temperatures of -25° C. They resist more to drought than other livestock (Sumar & Camino 1992).

• SACs have softer feet than other livestock, acting as a cushion, that do not lead to soil compaction and erosion to the same extent as other livestock or pack animals (Patterson & William 1996; Rodríguez & Quispe 2007; Sumar & Camino 1992).

Advantages of sheep:

• Sheep in general present a higher reproductive rate and better market access with higher prices for their meat and wool (Tichit 1995).

• Llamas and alpacas are often used in transhumant and agropastoral management systems, while sheep can also be used in nomadic systems (FAO 2001). No sources were found to confirm or disprove the successful use of SACs in nomadic systems.

Disadvantages of sheep:

• Grazing patterns of sheep affect slow growing pastures negatively (Sumar & Camino 1992).

• Sheep face sometimes problems with intoxication through the digestion of toxic plants. SACs rarely face intoxication by eating toxic plants in grazing conditions. They are more prompt to intoxicate since their digestion is slow but they developed aversion to eat new feedstuffs and toxic plants, what acts as a protection to intoxication (Sumar & Camino 1992).

Phrased differently, advantages of SACs compared to sheep are that they also thrive on poor pastures, are almost entirely being raised over 3000m altitude in fragile ecosystems where they are perfectly adapted to without causing degradation. Furthermore, they are an asset of the poorest people in Peru (De Soucy 2012).

2.2.4 Mixed herd management

Livestock production in arid environments is often characterized by the presence of different animal species managed together within family herds (Bonte et al. 1987, as quoted in Tichit & Genin 1997). Mixed grazing is defined by various species or class of animals grazing together on a given pasture (Nicol 1997). Mixed livestock systems involving sheep, SACs and to a lower extent cattle are common in the central Peruvian Andes (Flores et al. 2007).
Mixed herds have been a topic of interest and a matter of controversy for animal husbandry researchers and development practitioners. Some livestock scientists argue that specialization towards one animal species (SACs or sheep or others) would allow a better use of production factors while others suggest that through mixed herds farmers can better use the overall available forage by utilizing differences in animal’s reaction to a herbage resource, can better integrate seasonal energy requirements of animals and also can spread economic risks through diversification (Nicol 1997; Tichit & Genin 1997). Considering the vertical agro-ecological stratification of the mountain area, keeping various livestock species can especially in the Andean environment be seen as a better use of available pasture and risk reduction (Flores & Bryant 1989). Also Quispe et al. (2012) see mixed grazing as an alternative solution to improve the profitability of animal production due to a more uniform and efficient use of vegetation.

But mixed grazing also needs to be seen as a complex interaction between the available pasture (and its heterogeneity) and the grazing behaviour of the herbivore, as complementation (resulting in greater pasture utilization when dietary preferences of grazing animals are different and the vegetation resource is heterogenic) or competition (by overlap of the dietary preferences and necessities) of feedstuff can occur (Nicol 1997). Hertzberg and Kohler (2005) found that parasitic infestation was higher in SACs on farms that also kept sheep and/or goats. A good management is needed to avoid disadvantages and production loss by a mixed grazing system.

2.2.4.1 Mixed herds – Llamas and sheep

Physiological studies conducted by Genin & Alzérreca (2006) in arid highland conditions showed that llamas and sheep occupy complementary food niches and that there is little competition in the use of forages between the two species, as sheep prefer short grasses and llamas tall grasses. Mixed rearing is an effective strategy for managing production risks. Indeed, llamas and sheep have their own characteristics in terms of productivity and responses to environmental changes, which enable farmers to exploit their comparative advantages alternatively in terms of changes in production conditions (climate, marketing opportunities, etc.). Llamas can be seen as a component of system stabilization due to their ability to survive drastic climatic disturbances, while sheep have a significant growth rate. To ensure long-term sustainability of pastoral activity, Genin & Alzérreca (2006) recommend keeping both species on the same pasture.

Trials in North America show that llamas can be kept as guard animals to protect sheep from canine predators, as they act as active protectors of their flock (Franklin et al. 2012). This can also lead to a disadvantage, as sheep usually are kept being watched by a dog and llamas might attack the dog.

A disadvantage of mixed herds is disease spread between sheep to SACs (Sumar & Camino 1992).
2.2.4.2 Mixed herds – Llamas and alpacas
Alpacas prefer wetter places than llamas (bofedales) and need herbage that is slightly more nutritious and with a better digestibility and therefore are usually kept in single species herds (Sumar & Camino 1992). This also prevents the cross-breeding of llamas and alpacas, which is commonly not desired.

![Image: Mixed herd of llamas and alpacas]

2.2.4.3 Mixed herds – Alpacas and sheep
Pfister et al. (1989) found that llamas divided their grazing time evenly among tall, coarse bunchgrasses and low-growing grasses, while alpacas and sheep spent the majority of their grazing time consuming low-growing grasses and forbs, showing their occupation of the same ecological niche and therefore their competition between them.

Naupari (personal communication) although mentioned that sheep are very selective grazers, preferably grazing on short grasses, while alpacas are not as selective and also graze on taller grasses as *Calamagrostis* sp. Competition for grazing land between sheep and alpacas can occur, so good management is necessary to avoid detriments.

2.3 Economic aspects – sustainable livelihoods of smallholder farmers

2.3.1 Sustainable livelihoods and adaptability
Hazell et al. (2010) point out that for many low-income countries smallholder development remains a key option. Regarding equity and poverty reduction, there is a strong case for preferring small to large farms.

Still, smallholder farmers face diverse constraints: limited access or declining size to land and other (natural) assets, high levels of risk (personal, natural, economic and financial), lack of incentives in
their economic and institutional environments, difficulties in accessing appropriate markets, and the weak voice of smallholders’ organizations in policy debates. All these factors critically hinder the productive potential of smallholder farmers, especially of women (HLPE 2013). Another aspect is that even small scale farming can degrade the local environment. If no conservation techniques are applied properly, small scale farming can pose a risk to water and soil resources, threatening the own sustainability. This is of particular concern since a linkage between the environmental degradation and the farmer’s lack of access to human, social, and financial capital and information can be assumed (Hazell et al. 2010).

Here, the concept of “sustainable livelihoods” comes into play. First of all, the term “livelihood” will be defined: A livelihood encompasses the income generating activities pursued by a household and its individuals, and the social institutions, intra-household relations, and mechanisms of access to resources through the life cycle (Ellis 1998). The concept of sustainable livelihoods is a key factor in the debate about rural development, poverty reduction and environmental management (Scoones 1998). Chambers and Conway (1992) proposed the concept of sustainable livelihoods linking it to keywords as capability, equity and sustainability. The term livelihood refers to the capabilities, assets (including both material and social resources) and activities required for a means of living by an individual or household by combination of the individual or household’s assets, including activities and resources and access to these, mediated by institutions and social relations. Further, a livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base (Chambers & Conway 1992). Sustainable livelihoods are achieved through access to a range of livelihood resources (natural, economic, human and social capitals) which are combined in the pursuit of different livelihood strategies as agricultural intensification or extensification, or livelihood diversification (Scoones 1998).

Sustainable rural livelihoods imply that the means of livelihoods can be transformed and adapted by activities chosen by the farmers. Therefore it is important to assess the impact of agricultural and other production practices on sustainable rural livelihoods. Farmers in rural communities may be either self-employed (typically in farming) or involved in multiple livelihood activities (including non-farm activities). Hence, rural livelihoods tend to be very heterogeneous and dynamic (Tang et al. 2013).

As already highlighted above, livestock as a main livelihood component and livestock keeping as an income-generating activity are fundamental to many of the world’s poorest people. According to Delgado (1999) poor and landless people derive a higher proportion of household income from livestock sources than do those with greater wealth living in the same communities.
Livestock comprise one of the assets that make up a household’s asset portfolio. Various livestock species, as typically kept in the Peruvian Andes, diversify the household’s income, also considering that different livestock have multiple livelihood functions. Those with more assets (and livestock species) tend to have a greater range of economic options and a buffer to increase resilience and secure their livelihoods (Anderson 2003). But Birner (1999) points out that livestock as an asset have ambiguous implications with respect to risk. Livestock are easily disposed of and can be sold in case of financial emergency, but have disadvantages as well due to susceptibility of diseases, theft, accidents, maltreatment and neglect.

Scoones (1998) identified three broad clusters of livelihood strategies that are viable for rural communities: Agricultural intensification/extensification, livelihood diversification or migration. Through processes of intensification (more output per unit area through capital investment or increases in labour inputs) or extensification (more land being used) communities can either earn more from agriculture and livestock, or they can diversify to a range of non-farm income activities (as mining, business, transport), or farmers leave the rural area and move to urban areas to work in something completely different.

Here adaptability of farmers to different external situations becomes “a key aspect of farm survival” (Darnhofer et al. 2010). Hence, the authors describe three major forces that strengthen the adaptive capacity of farming systems: the process of learning through experimentation and monitoring (i.e., the capacity of farmers to generate and integrate new knowledge), the flexibility to increase opportunities for response (e.g., adapting herd composition or work organisation) and a diversity of resources, production processes and products to cope with variability.

2.3.2 Diversification versus specialization of livestock production in the Peruvian Andes
The traditional subsistence system in the Andes is highly based on diversification of resource exploitation in order to minimize risks, increase resilience and assure farmer’s survival in the harsh mountainous climate. Adaptation to stress and shock is an important dimension of family welfare (Valdivia 2001).

Van’t Hooft (2002) recognized two common livestock production strategies: diversification and specialization. These strategies have to be considered as the two extremes of a continuum, with many variations in between. Kristjanson et al. (2007) showed in their paper that diversification of income through livestock and intensification of livestock activities through improved breeds has

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5 Resilience refers to the short-term capacity to return to a state of equilibrium and maintain functionality when the system is confronted with a strong punctual perturbation (Masera et al. 2000; as cited in Bernués et al. 2011).
helped households to escape poverty in some Peruvian provinces. Also diversification of livestock production that resulted in new livestock products to the household, as fibre and wool, cheese, eggs, milk and others, helped to improve the household income. Still the importance of livestock farming itself in terms of a pathway out of poverty is a controversial topic, as Kristjanson et al. (2007) support the argument that non-farm diversification and crop diversification are more important factors for escaping poverty than animal husbandry.

Not only the question if, but also the question how to diversify is not easy to answer. In a study realized by Udo et al. (2011) it was shown that, considering the choice of which livestock species should be kept in order to earn the highest income, smallholder milk production, based on European dairy breeds or crossbreds, proved to be a good means to increase household incomes. This shows the paradox that small ruminants (or poultry, pigs) might better fit into the farming conditions of smallholder farmers, but their contribution to household incomes is small.

In a report about a program that is intent to improve the livelihood of alpaca farmers in Peru’s poorest region, Huancavelica, diversification is seen as a loss of animal productivity and resources, and specialization was the suggested production strategy (Flores Mogollón 2009). Specialization of livestock production might lead to more efficient production strategies and outcomes, and therefore a higher profit. But the disadvantage is that specialization also increases the vulnerability of farmers when considering changes in markets, sudden morbidity or mortality of livestock, climate change effects and other aspects (Tarawali et al. 2011).

Yang & Liu (2012) conclude as well that raising the level of agricultural specialization is an important factor to promote rural economic growth, but restrictions of market scale, farmland fragmentation and other factors make it difficult to improve the level of agricultural specialization. As well the move from mixed agriculture - livestock farming towards greater specialisation, together with the general intensification of food production have had adverse effects on the environment (Hooda et al. 2000). So the question if specialization is feasible in all rural areas and especially in the context of the Peruvian high Andes still persists.

2.3.3 Diversification versus specialization of rural livelihoods and economic activities – farm and non-farm incomes

Livelihood diversification refers to individuals and households that raise their incomes with complementary sources and spread and reduce economic risks. Livelihood diversification includes both on- and non-farm activities which are undertaken to generate income additional to that from the main household agricultural activities, via the production of other agricultural and non-
agricultural goods and services, the sale of waged labour, and other strategies undertaken to consolidate the farm economy and reduce risk (HLPE 2013; Hussein & Nelson 1998).

According to Hussein & Nelson (1998) the majority of rural producers have historically diversified their productive activities to encompass a range of other productive areas. Also Barrett et al. (2001), Davies et al. (2009) and Deininger & Olinto (2001) argue in their papers that diversification is the norm, stating that very few farmers collect all their income from only one source. Non-farm activities are widely recognized as being a crucial way of income diversification to rural communities. Mainly rural households in risky environments (as the high Andes can be seen) tend to diversify their income sources (Reardon et al. 2000).

Rural non-farm incomes are generated in manufactures and services, excluding incomes from activities in the fields of agriculture, livestock, fishing and hunting (Lanjouw & Lanjouw 2001). Another definition by Haggblade et al. (2009) is the inclusion of „all economic activities other than the production of primary agricultural commodities. Non-farm, thus, includes working in mining operations, manufacturing, construction, business, transport, and a full range of financial, personal, and government services. Agroprocessing—the transformation of raw agricultural products by milling, packaging, bulking, or transporting—forms a key component of the rural non-farm economy“.

Non-farm activities must be understood as a complementation of agriculture, both are linked through investment, production, and consumption throughout the rural economy, and both form part of complex livelihood strategies adopted by rural households (Davies et al. 2009).

Diversification of activities, incomes and assets is done due to various motives, which can be summarized into two main factors (Barrett et al. 2001; Deininger & Olinto 2001; Lanjouw & Lanjouw 2001; Reardon et al. 2001):

1. Push factors: including risk minimization, lack of access to productive resources as land, diminishing family labour supply, reaction to crisis or liquidity constraints, high transactions costs that induce households to self-provision in several goods and services, missing markets

2. Pull factors: Realization of strategic complementarities between activities, such as crop-livestock integration or milling and hog production, higher income generated, potentially lower risk and greater social status by non-farm activities, good farm mechanisation

The interaction of push and pull factors with the agricultural and economic setting of an area shape the overall importance of farm or non-farm activities (Deininger & Olinto 2001).
Following Berdegué and Fuentealba (2011, as cited in HLPE 2013) about 65 percent of smallholder farmers worldwide rely significantly and increasingly on non-farm sources of income to sustain their livelihoods. Also in Latin America non-farm activities are crucial to households, counting up to 40% of rural income. These activities need to be recognized in their importance, as they help to alleviate rural poverty (Reardon et al. 2001). The contribution of non-farm income and activities to societies has been growing substantially over the last decades and is likely to continue growing in view of globalization (Deininger & Olinto 2001).

But is the economic diversification to non-farm activities the solution?

Given the importance of non-farm income to rural economies, the contribution of non-farm employment to household welfare is still not completely understood. Also whether diversification to non-farm activities can be seen as a strategy to move out of poverty and under what conditions rural non-farm employment increases or decreases rural or gender equality still needs to be answered. Case studies from Latin American, Asian and African countries show mixed results.

Canagarajaha et al. (2001) and Newman at al. (2000) describe in the context of Ghana and Uganda that non-farm participation was associated with lower poverty levels and greater reductions in poverty over time, mainly for female-headed households. Wage income as non-farm earnings contribute to reducing inequality, and lower income groups also benefit due to strong overall growth in non-farm earnings. For several countries in Africa, Reardon (1997) points out that farmers get more stable incomes from the non-farm sector the whole year round, smoothing the consequences of not sufficient income from agricultural work due to seasonal patterns.

Deininger & Olinto (2001) and Reardon et al. (2000) found out that access and income from non-farm activities depend on various factors as education, household size, location (as poorer households tend to be located in the hinterlands of the rural space), gender, age and type of work performed. So the same conditions that create or maintain an unequal agricultural income distribution also affect the level and distribution of non-farm income. Wealthier people are more likely to earn a higher income through non-farm employment. This could lead to increased concentration of wealth and higher economic inequalities.

Also to other authors non-farm activities are a mixed blessing. Lanjouw (1998; as cited in Canagarajaha et al. 2001) found that inequality in rural Ecuador increased as a result of non-farm activity, while Adams (1994) found that inequality decreased in rural Pakistan with the growth of non-farm activities.
Lanjouw & Lanjouw (2001) argue that if the bulk of non-farm income goes to the richer segments of society then it is inequality increasing. Also Davies et al. (2009) and Escobal (2001) argue that promotion of non-farm activities may leave poor households behind and exacerbate rural income inequality, when entry barriers in terms of liquidity or human capital constraints are not eliminated. Reardon et al. (2000) state that non-farm employment tends to increase inequality in Africa (due to the disability of the poor to overcome important entry barriers to many non-farm activities) and to decrease inequality in Latin America.

Better opportunities in the non-farm sector draw labour away from the farm, what might reduce farm output (Reardon et al. 2000). Inequalities between women and men can also get stronger. Individual asset holdings can influence non-farm activity gender distributions, meaning that women are more likely to undertake labour-intensive, low-skill, low entry barrier jobs with low remuneration than men (Davies et al. 2009; Lanjouw & Lanjouw 2001; Reardon et al. 2000). Kristjanson et al. (2007) show that strategies for helping to lift rural households out of poverty should focus on various income diversification strategies, including crops, livestock and non-farm options.

Diversification of income sources is also important to the Peruvian household economy. According to Escobal (2001), 51% of the net income of rural households comes from non-farm activities in Peru, experiencing a substantial growth in the last decade. This shows that the rural sector is much more than just farming.

So what about specialization of the household’s income sources regarding on-farm and non-farm activities? Davies et al. (2009) describe in their paper what factors constitute diversification or specialization at the household level. They examined the degree of specialization and diversification by defining a household as specialized if it receives more than 75% of its income from a single source and diversified if no single source is greater than that amount. When households do specialize, in a majority of cases this specialization is in on-farm activities, although the percentages become lower the higher their income is. At higher income levels specialization in non-agricultural wage becomes more important.

Also Deininger & Ollinto (2001) argue in their paper about non-farm income in Colombia that specialization, in the agricultural context and also outside of agriculture, increases the household’s income and assets. Specialized households relying on only one income source increased their welfare and had a higher income than diversified ones. Adoption of diversified strategies reduces household welfare and also total production. Barriers to specialization are many times imperfections in markets for credits and land, lack of education and inequalities in asset ownerships. This leads to lost opportunities in non-farm employment, as poorly educated farmers usually work in low-income jobs.
According to their findings, households that adopt multiple income-generating strategies obtain a relatively low wage. By contrast, adopting a specialized strategy more than doubles their wages. Rural households unable to specialize use non-farm employment to earn some extra income. Other findings of Deininger & Ollinto were that higher education leads to specialization and the household number also determines the production strategy, as big households rather diversify than specialize. Non-farm employment offers increased opportunities for enhanced specialization which increase the welfare and the capacity to invest of households, providing the basis for long-term development of the rural sector.

3 Objectives

The main objective of this master thesis is to investigate the income-generating and production strategies of livestock keepers. Further the choice of livestock species in smallholder farmers in the Andean rangelands of Pasco, the farmer’s perception of their own livestock and the perceived effects of climate change are investigated.

Possible production strategies within the livestock sector are specialization of one species or a few different species, or diversification of livestock. Within the whole economic sector possible strategies are alternative income generation by crop agriculture or off- and non-farm economical activities. These different strategies imply advantages and disadvantages for the farmer, which will be also further investigated in this research together with the question of the perceived susceptibility to climate change and the future of SACs in the study region.

Specific objectives:

i. To describe the importance of livestock production and non-farming activities to the household’s income and the role Andean livestock plays for income generation.

ii. To document farmers’ perceptions on the adaptation of llamas, alpacas and sheep to the harsh Andean environment (water scarcity, pasture quality and low temperatures) and their advantages and disadvantages in economical and management aspects

iii. To assess farmers’ perceptions on climate change and its impact on their production and livelihood strategies.

4 Research questions

Based on the objectives of the study the following research questions were defined:
1. What are the characteristics of the chosen income-generating and production systems?
   1.1. Why do some farmers diversify their economic activities to non-farm income and why do others specialize in animal husbandry?
   1.2. Why do some farmers specialize in one type of livestock and why do others diversify their livestock?

2. What is the farmer’s perception of the advantages and disadvantages of each livestock species and of the chosen strategy?

3. To what extent is climate change perceived as a production problem?

4. What type of improvements can be done, what recommendations can be given?

5 Participants, material and methods

5.1 Case study area
The research was carried out in Lima, Cerro de Pasco and its villages around (provinces of Pasco and Daniel Carrion) in August 2013. These provinces belong to the department of Pasco, which is situated east of Lima in the Central Andes of Peru, having sierra and selva ecosystems (Zárate 2008). Other bordering departments are Huánuco to the north, Junín to the south, and Ucayali to the east (Fig. 4).
The red circle shows zone 1 and the blue circle shows zone 2. This zonation was made according to different provinces where the interviews were conducted. Zone 1 is Pasco province and zone 2 is Daniel Carrión province.

The Pasco province, a part of the Pasco department, has an area of 4 758 57 km² and a population of 150 717 inhabitants with a population density of around 32 people per km². The province of Daniel Carrión has an area of 1 887 23 km² with 47 803 inhabitants and a population density of 25 people per km² (Zárate 2008). The capital of the whole department is Cerro de Pasco, which was the base for the interview excursions. The origin of the city of Cerro de Pasco (highest city in the world with more than 50 000 inhabitants at 4 380m) dates back to the discovery of rich mineral deposits in the year 1630. Since then the mining industry affects the whole region, extracting mostly lead, zinc, copper, gold and silver (Zárate 2008). Cerro de Pasco is rapidly growing with a projected population of 91,497 inhabitants for the year 2015, from 61,065 inhabitants in 2007 (Pasco Regional Government 2010).

Because of the mainly high altitude of the study region (4000 to 4380 masl, but some villages were also lower), the climate of the study area is cold with an annual average temperature of 5°C with a minimum temperature of -11°C and a maximum temperature of about 15°C. Rainy season is between
November and March (being therefore the winter season), the other months are rather dry (summer season). The annual mean precipitation is about 900 to 1000 mm (Plasencia, s.a.; fig. x).

![Climate data of Cerro de Pasco (Climate diagram 2013)](image)

**Figure 5: Climate data of Cerro de Pasco (Climate diagram 2013)**

About 24 000 people are working in agriculture and livestock husbandry (Pasco Regional Government 2010). Due to the climatic conditions in this region, the most important livestock are SACs, representing a large percentage of their income source from selling fibre and meat, one of the main sources of economic resources in Pasco region (Zárate 2008). The number of llamas is about 38 600, representing 3.10% of the total national population, which are raised mostly by smallholder farmers in mixed flocks composed of alpacas, llamas, sheep and cattle. Further, there are about 148 000 alpacas (with an increasing tendency) and 540 000 sheep (with a decreasing tendency) in the department (INEI 2012; MINAG 2010). Apart from animal husbandry, the other important work sectors are businesses and minery (Zárate 2008).

According to INEI 2012, Pasco department has a negative migration balance with people moving to Lima and its surroundings, or to the other neighbouring departments of Junin and Huánuco in search of better work and education opportunities or simply because of the better climate and the lower altitude. Chronic desnutrition is still a problem in Pasco, especially for women and children under 5 years of age. About 52% of the population are classified as poor, and within these 52% about 19% are classified as extremely poor to Peruvian standards (Zárate 2008 and references therein). In other words, the Pasco department is located at 7th place (out of 25) regarding the total poverty and 4th place regarding extreme poverty at the national level.
In the province of Daniel Carrión 36.2% of the population live in extreme poverty, mostly affecting the districts of Santa Ana de Tusi, Chacayán and Yanahuanca. In the province of Pasco 15% of the population live in extreme poverty and the districts of Paucartambo and Ninacaca are considered poorer than the average of the whole department Pasco. The economy of Daniel Carrión is marked by a more favourable climate for crop production due to a lower altitude. But road access to main markets is worse, explaining the economic disadvantage (Gobierno Regional de Pasco 2010).

5.2 Data collection and survey methodology

A sociologic case study approach was chosen to investigate contemporary livelihoods within their real life contexts, which allows emphasizing on the connections between ecologic and economic factors in the case study area (Feagin, Orum & Sjoberg, 1991; Yin 2009).

The preparation started with intensive literature reviews using bibliography from online databases, the libraries at BOKU and Universidad Nacional Agraria La Molina (UNALM) and the attendance of university lectures dealing with the topic at UNALM.

A big part of the research and all the interviews with farmers and experts were conducted in Spanish language. Communication in the interviewees’ mother language brings advantages as not having to use a translator and being accepted more easily in the research community because of direct communication (Hangartner 2012).

For the farmer’s interviews a semi-structured questionnaire (see Annex) including closed and open questions was developed for data collection, to ensure that all participants answer the same questions, so that their responses can be compared.

In order to obtain information from the respondents about their living conditions and livestock keeping management, the questionnaire was based on following chapters: (1) general information, (2) on-farm and non-farm income\(^6\), (3) natural resources, (4) climate change, (5) livestock, and (6) production strategies – diversification or specialization.

The household was seen as the unit of analysis. To gain quantitative data, ratings were used for comparisons and weighing of different economic and ecologic aspects of SACs and sheep, meaning that 1 or “+” means the best or highest value, 2 or “~” for the medium and 3 (or 4, depending on the species size) or “−” the lowest. As Markemann et al. (2009) remind, in a ranking or rating approach always one function is being ranked or rated over the other. Automatically one function results to be

\(^6\) Here also replies concerning off-farm income were accepted, as generating income from agriculture or animal husbandry at a different farm.
the bottom ranked on average. This does not imply, however, that the specific function is of no importance or even meaningless. It means that the general statement is put in relation to the other proposed functions.

In some questions past developments and trends were investigated. The time limit for these questions was 5 years, but when farmers did not remember their status 5 years ago, I reformulated the question for past developments and trends within the last 5 to 10 years.

For many questions multiple answers were possible and accepted.

Answers given were recorded on questionnaires and later inserted into MS Excel 2010 and IBM SPSS 20 for further analyses (see chapter 5.3 Data analysis).

To find out about differences between the interviewed farmers, the 47 farmers were separated into the two different provinces where they live (23 in the province of Pasco and 24 in the province of Daniel Carrión).

To inform the community about the data collection, I presented and introduced myself and my project at a workshop of SAC-breeders on the 6th and 7th of April 2013 that took place in the building of the ministry of agriculture in Cerro de Pasco, with the help of Dr. Gustavo Gutierrez Reynoso from the Agrarian University La Molina, Lima (UNALM), who is involved in community projects in this area for many years. Apart from that, I also gave a short interview about my research for a local radio station in the same event.

Atteslander (2008) calls “trial interviews” crucial to obtain reliable results. So during the yearly livestock fare in Ninacaca, Pasco in the week from 24th of June to the 1st of July, trial interviews were conducted with five SAC- and sheep farmers to check the applicability of the questionnaire. As the questionnaire was changed after this trial, only one of the conducted interviews was used for the master thesis, after having visited the farmer again to ask some additional questions that were not in the questionnaire in the first place.

To get deeper information and close knowledge gaps, qualitative expert interviews were completed as additional research instruments. Participants were Ing. Mabel Palomino Toscano, a livestock researcher from UNALM who does investigation in the study area on similar livestock topics, with Dr. Javier Arturo Ñaupari Vásquez, professor of livestock sciences at UNALM and Ing. José Ruíz Chamorro, another livestock researcher from UNALM who originates from the study area. These expert interviews were used for their contextual information and no proper analysis was done.
During the field trip, a research diary was used to make notes of interesting observations that helped to get a broader understanding of the farmer’s living conditions.

5.3 Participants

In total, 53 interviews were carried out (5 of them in the trial phase) with individual farmers, of which 46 were used for this master thesis (Table 2).

Table 2. Number, districts and provinces of interviewees

<table>
<thead>
<tr>
<th>Province</th>
<th>District</th>
<th>Number Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasco</td>
<td>Simon Bolivar</td>
<td>7</td>
</tr>
<tr>
<td>Pasco</td>
<td>Ninacaca</td>
<td>6</td>
</tr>
<tr>
<td>Pasco</td>
<td>Paucartambo</td>
<td>4</td>
</tr>
<tr>
<td>Pasco</td>
<td>Tinyahuarco</td>
<td>4</td>
</tr>
<tr>
<td>Pasco</td>
<td>Yanacancha</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>Zone 1</td>
<td>22</td>
</tr>
<tr>
<td>Daniel Carrion</td>
<td>Santa Ana Tusi</td>
<td>22</td>
</tr>
<tr>
<td>Daniel Carrion</td>
<td>Yanahuanca</td>
<td>1</td>
</tr>
<tr>
<td>Daniel Carrion</td>
<td>Chacayan</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>Zone 2</td>
<td>24</td>
</tr>
</tbody>
</table>

Selection criterion for eligible households was the existence of either llamas or alpacas or both in their herds. Participants were on the one hand selected from a database of interviews that were conducted in 2011 and 2012 by master and PhD-students of BOKU and UNALM, and on the other hand, in cases where it was difficult to locate the previously interviewed people, available farmers keeping SACs and living in the Pasco department were chosen for the interview. The participant’s data were anonymized.

The average interview time was about 20-25 minutes, depending on the talkativeness of the respondent and the circumstances of the interview. Interviews were mostly conducted outside the farmer’s houses, sometimes inside their houses, at the street or in a restaurant. The expert interviews took longer, about 45 minutes to one hour each, and were all conducted at UNALM.

The farms were accessible by roads and by walking distances of not more than 20 minutes.
5.4 Data analysis
The data obtained were coded and entered into MS Excel 2010. Minimum, maximum, mean values, frequencies, percentages and standard deviations were calculated and tables and graphs were created. Then the statistical software SigmaPlot 11.0 was used for graphs.

As the sample size of 46 farmers was very small, many variables did not fulfill the conditions for statistical tests.
5.5 The study’s limitations

The study design had some limitations, as not all farmers easily understood percentages of income and specialization aspects.

To assess the applied production strategy in terms of specialization or diversification, farmers were initially asked, if they earned 75% or more of their income from only one or two livestock species. As many farmers had difficulties calculating in percentages, circles were drawn to show the farmers an illustrated version of the question. To further help farmers to make the question clear, they were additionally asked if they used more resources, attention and time to take care of one livestock type than for the others, and to what degree this focus was given. So when comparing the answers given by the farmers with the actual number and species of animals they keep, my method of asking for their production strategy might not have been suitable in some situations. Looking at the actual production strategies (livestock species and numbers kept) and comparing them with the answers of the farmers, some discrepancies can be found. In the end only farmers just keeping two main livestock species were considered as being specialized, this was five farmers altogether. But in the survey twelve people claimed being specialized in their own perception. Of the five farmers specialized in the sense that they only have two livestock types, two have much more animals of one type than of the other, two have similar numbers of the two species and one is obviously specialized in two species and their numbers he keeps.

Also giving percentages in general was not easy for farmers who only completed primary education. When asked for the percentage of the household income coming from non-farm activities, some farmers did not answer. Then I suggested them to see it as half-half for instance. Thereupon many of these farmers affirmed my suggestion, claiming that half of their household’s income comes from animal husbandry. If the figure itself is right or was just repeated and confirmed by the farmer could not always be verified.

Naupari and Ruiz (personal communication) argued in the expert interviews, that farmers should cooperate and organize themselves to represent the interests of their vulnerable rural communities.

6. Results

The results are divided into four mayor sections. First, the interviewed smallholders of the research areas are described by their socio-economic characteristics and activities.

The second section deals with livestock production in the research villages and related characteristics as current livestock types, numbers and herd sizes; past perceived trends and future projections of
herd size developments, perceived advantages and disadvantages of SACs and sheep and of the chosen production strategies.

The third section deals with the current state and past perceived developments of natural resources (pasture quality and water availability). Further, climate change perceptions are depicted and its implications for livestock production are illustrated.

The last section displays future perspectives and farm developments that were thought of by the farmers. Here projections of planned production improvements and changes of income sources are presented. Causes that might lead to an emigration and abandonment of the farms and personal wishes that should be realized to make it easier for the farmers to remain on their farms and keep working in animal husbandry are highlighted.

When differences were detected, the results are shown for the two different zones, the provinces of Pasco and Daniel Carrión.

6.1 Socio-economic information

In the first chapter, general socio-economic aspects of the interviewed farmers are illustrated. Further, economic activities are presented and the importance of livestock production is highlighted.

6.1.1 Socio-economic aspects

The interviewed farmers were 30% females (zone 1: 48%, n=22; zone 2: 12%, n=24) and 70% were males. The average age was 45.4 (±13.8) years. Comparing the two zones, the average age (for both women and men) was 49.9 (±14.4) years in zone 1 and 43.5 (±12.5) years in zone 2.

The civil state was similar distributed between the two zones. About three fourths of the people were married, just a few were widowed, cohabitated, or were separated. Four farmers were single.

The majority of the interview partners have finished school, most farmers even finished secondary school. Illiteracy was found only in two cases and it was restricted to older women (Table 3).

<table>
<thead>
<tr>
<th>Category</th>
<th>Illiterate</th>
<th>Primary school</th>
<th>Secondary school</th>
<th>Higher education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 (n=22)</td>
<td>9.1</td>
<td>18.2</td>
<td>59.1</td>
<td>13.6</td>
</tr>
<tr>
<td>Zone 2 (n=24)</td>
<td>0</td>
<td>42</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>4.3</td>
<td>30.4</td>
<td>45.7</td>
<td>19.6</td>
</tr>
</tbody>
</table>

Looking at the household structure, on average 5.1 people were living in every interviewed household. 2.4 people out of 5.1 were earning an income, 2.3 of those worked in livestock production. Most of the farmer’s children either attended school, or, when they were older, either
worked in a different profession than animal husbandry and/or lived in the city or a different province. Only few farmers had children who worked in the traditional profession of livestock production and planned to stay in the case study area.

### 6.2.2 Income-generating strategies

All of the interviewed farmers either worked themselves in animal husbandry or had at least one household member who did so. About 45% earned their whole income through livestock production and didn’t engage in any other type of income-generating activity. Comparing the two zones, in zone 1 smallholders earned less income working in animal husbandry than in zone 2.

Table 4 reveals the share of household income farmers got from working in animal husbandry on average. The number 100% indicates that all farmers in both zones only earn income from livestock production and do not engage in other employments. The other percentages show a decreasing value of income generated by animal husbandry.

<table>
<thead>
<tr>
<th>Livestock income</th>
<th>100%</th>
<th>99% - 51%</th>
<th>50%</th>
<th>&lt;50%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 (n=22)</td>
<td>36.4</td>
<td>22.7</td>
<td>22.7</td>
<td>18.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Zone 2 (n=24)</td>
<td>50.0</td>
<td>25.0</td>
<td>16.7</td>
<td>8.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Both zones</td>
<td>43.2</td>
<td>23.8</td>
<td>19.7</td>
<td>13.2</td>
<td>100.0</td>
</tr>
</tbody>
</table>

In an attempt to classify the group of farmers who earn 100% from livestock keeping from farmers who also engage in non-farm activities, few differences could be found. Of all 20 farmers who earn 100% from livestock keeping, 65% lived in zone 2. Average age and education level were similar, so no proper characterizations for this group could be made.

Table 5 gives an insight on the non-farm activities carried out by the farmers. These activities were very diverse and are briefly described here. One farmer worked, apart from animal production, as well in handicraft, three people (all in zone 1) in business, ten in occasional jobs (meaning they worked in different areas, usually not for longer time periods), three people worked in as teachers or in investigation, three more in construction, five in transport and two in the local cooperative. Reasons for farmers working in non-farm employment were all economic, to earn a better and more reliable income. Additionally, some farmers specified that they needed more income as their children studied, or explained that working outside of their farm obviously gave them more employment opportunities.

Apart from livestock, four farmers or their household members, all living in zone 2, engaged as well in agriculture. This was done rather for auto-consumption than for making a living. Main crops
planted were potatoes, maca (an Andean tuber) or oat for animal feed. One of the farmers mentioned breeding and selling of dogs as an on-farm activity.

**Table 5. Non-farm employments of interview partners**

<table>
<thead>
<tr>
<th></th>
<th>Occasional jobs</th>
<th>Transport</th>
<th>Construction</th>
<th>Business</th>
<th>Teacher/Investigation</th>
<th>Cooperative</th>
<th>Handicraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 (n=22)</td>
<td>22.7</td>
<td>13.6</td>
<td>9.1</td>
<td>13.6</td>
<td>4.5</td>
<td>9.1</td>
<td>0</td>
</tr>
<tr>
<td>Zone 2 (n=24)</td>
<td>20.8</td>
<td>8.3</td>
<td>4.2</td>
<td>0</td>
<td>8.3</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>Total</td>
<td>27.1</td>
<td>10.9</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
<td>4.3</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Another investigated aspect was the previous importance of livestock production for the household income, basically to see if the share of income from non-farm activities increased within the last 5 years. Out of 46 farmers, 24% answered that at present animal husbandry was more important than it used to be in the last 5 years, for 63% of farmers its importance stayed the same and for 13% animal production was less important for the household income nowadays than before.

Regarding the time spent working in non-farm activities (n=26 farmers), it was most common for the farmers or household members to work every day or almost every day in non-farm activities (39%). Working a few times per month or infrequently was also common (19% each). Other 15% worked a few days a week outside their farms and 8% worked a month in the year, mostly in construction work. Five to ten years ago about 33% farmers spent more time working in non-farm activities, about 37% worked to the same extent in non-farm activities as nowadays and about 30% worked less time than nowadays.

When asked for a possible lack of time for animal husbandry, about 85% of farmers who engaged in non-farm employment said that they still had enough time for their animals, about 15% said that they did not.

**6.2.3 Motives for livestock keeping**

Livestock play many roles in the lives of people. To understand the smallholder’s motives to choose their livestock species, farmers were asked what purposes did their animals fulfil for them and what products they used from their animals (Table 6). Sample size was according to the numbers of farmers who keep the main livestock species and multiple answers per species were accepted. All farmers used these four main livestock species as a source of meat and their cattle also for milk production. Alpacas and sheep were always used for fibre production, llamas to some extent as well. Other uses were as pack animals (only llamas), for their hides, for manure, and to a smaller extent for sale as breeding animals. Some farmers mentioned that they kept their livestock simply out of traditional purposes, as livestock have always been part of their daily life.
6.2.4 Earnings from livestock

To further investigate the economic importance of livestock production in the research areas, the farmers were asked to do a ranking of which livestock type brings them most earnings (Fig. 1). The farmers were asked to compare and rank their ruminant livestock species and SACs, starting with the animal that stands for the highest earning value. Not all farmers kept all four species, some only kept two or three. To properly compare the answers given, only the 17 farmers keeping all four species were requested to participate and these results are shown here.

The lowest earnings most farmers got from llamas. Farmers who said that they earned their highest income from llamas did so because they sold llama meat as alpaca meat. The highest earnings farmers got from cattle. Between these extremes, sheep and alpacas show similar figures.

Few farmers said that the different main livestock species were all the same to them economically, one person got most earnings from cattle and llama together, two people said alpaca and sheep together. These results are not displayed in the graphs.

---

Table 6. Motives for livestock keeping in percentage

<table>
<thead>
<tr>
<th>Species</th>
<th>Meat</th>
<th>Fibre/Wool</th>
<th>Milk</th>
<th>Manure</th>
<th>Pack animal</th>
<th>Hide</th>
<th>Tradition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Llama (n=42)</td>
<td>100</td>
<td>69.0</td>
<td>0</td>
<td>64.3</td>
<td>69.0</td>
<td>76.2</td>
<td>14.3</td>
</tr>
<tr>
<td>Alpaca (n=44)</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>56.8</td>
<td>0</td>
<td>63.6</td>
<td>13.6</td>
</tr>
<tr>
<td>Sheep (n=40)</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>60.0</td>
<td>0</td>
<td>72.5</td>
<td>15.0</td>
</tr>
<tr>
<td>Cattle (n=24)</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>20.8</td>
<td>0</td>
<td>45.8</td>
<td>25.0</td>
</tr>
</tbody>
</table>

*Multiple replies were possible*
6.2 Livestock and livestock production strategies

In this chapter, the status-quo of livestock numbers is described. An overview is given on perceived developments of livestock herd sizes in the past and expected trends in the future. To assess the perceived ecological and economical suitability of livestock in terms of adaptation to the harsh environment and market opportunities, comparisons between sheep and SACs were made and the results are displayed. Further, production strategies as diversification or specialization of various livestock types are analysed and reasons for the chosen production strategy are illustrated.

6.2.1 Livestock numbers

Farmers kept a big range of livestock species. The highest livestock numbers were represented by alpacas, sheep, llamas and cattle, which are named here as main livestock. The most commonly livestock kept were alpacas with a mean of 102 animals (n=44). The second most common species were sheep with a mean of 75 animals (n=40) and llamas with 36 animals (n=42). Cattle were not so common with about 10 animals as the mean value (n=24).

Not all interviewed farmers kept all main livestock types. Table 7 displays the mean numbers and the standard deviation of each main livestock species, the minimum and maximum values and the distribution (presented in percentages) between the two zones.
To find out about the husbandry of different breeds within the main livestock types was not of main focus in this work. For llamas, mainly K’ara type was observed, as they are mostly being used for meat production, and a few farmers had either Intermedio type or Chaku type. For alpacas the common breed was Huarizo, Suris were not observed. Sheep breeds were mostly Criollo, Corriedale and few Hampshire and Junín. Commonly seen cattle breeds were Brown Swiss and sometimes Criollo.

Horses, pigs, guinea pigs, trouts, chickens, rabbits and ducks are referred to as “other” livestock. Most farmers kept those as well (87%). Horses are used for transport only and not for meat production. These other livestock species are usually kept in small numbers per farm, although two farmers were specialized to a big extent in trouts and guinea pigs. Table 8 displays the same information as in table 5 for these livestock.

Table 7. Numbers of main livestock per zones

<table>
<thead>
<tr>
<th>Zones</th>
<th>Species</th>
<th>Mean ± SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 (n=22)</td>
<td>Llama</td>
<td>29.4 ± 22.7</td>
<td>6</td>
<td>100</td>
<td>42.2</td>
</tr>
<tr>
<td></td>
<td>Alpaca</td>
<td>120.4 ± 108.3</td>
<td>10</td>
<td>400</td>
<td>55.1</td>
</tr>
<tr>
<td></td>
<td>Sheep</td>
<td>80.8 ± 81.6</td>
<td>10</td>
<td>300</td>
<td>53.2</td>
</tr>
<tr>
<td></td>
<td>Cattle</td>
<td>5.1 ± 2.5</td>
<td>2</td>
<td>10</td>
<td>27.9</td>
</tr>
<tr>
<td>Zone 2 (n=24)</td>
<td>Llama</td>
<td>42.6 ± 27.0</td>
<td>4</td>
<td>110</td>
<td>57.8</td>
</tr>
<tr>
<td></td>
<td>Alpaca</td>
<td>89.8 ± 72.3</td>
<td>5</td>
<td>280</td>
<td>44.9</td>
</tr>
<tr>
<td></td>
<td>Sheep</td>
<td>72.1 ± 41.1</td>
<td>20</td>
<td>150</td>
<td>46.8</td>
</tr>
<tr>
<td></td>
<td>Cattle</td>
<td>13.1 ± 12.5</td>
<td>2</td>
<td>40</td>
<td>72.1</td>
</tr>
</tbody>
</table>

Table 8. “Other” livestock species numbers

<table>
<thead>
<tr>
<th>Zones</th>
<th>Species</th>
<th>Mean ± SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 (n=22)</td>
<td>Horse</td>
<td>2.8 ± 1.3</td>
<td>1</td>
<td>5</td>
<td>58.6</td>
</tr>
<tr>
<td></td>
<td>Pig</td>
<td>2.3 ± 0.6</td>
<td>2</td>
<td>3</td>
<td>53.8</td>
</tr>
<tr>
<td></td>
<td>Guinea pig</td>
<td>15.4 ± 9.3</td>
<td>2</td>
<td>25</td>
<td>35.8</td>
</tr>
<tr>
<td></td>
<td>Rabbit</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Chicken</td>
<td>5.2 ± 3.5</td>
<td>2</td>
<td>14</td>
<td>47.9</td>
</tr>
<tr>
<td></td>
<td>Duck</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Trout</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zone 2 (n=24)</td>
<td>Horse</td>
<td>1.9 ± 1.0</td>
<td>1</td>
<td>4</td>
<td>41.4</td>
</tr>
<tr>
<td></td>
<td>Pig</td>
<td>2.0 ± 1.0</td>
<td>1</td>
<td>4</td>
<td>46.2</td>
</tr>
<tr>
<td></td>
<td>Guinea pig</td>
<td>30.1 ± 53.2</td>
<td>2</td>
<td>200</td>
<td>64.2</td>
</tr>
<tr>
<td></td>
<td>Rabbit</td>
<td>3.8 ± 4.2</td>
<td>1</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Chicken</td>
<td>4.8 ± 3.3</td>
<td>2</td>
<td>12</td>
<td>52.1</td>
</tr>
<tr>
<td></td>
<td>Duck</td>
<td>4.5 ± 3.9</td>
<td>1</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Trout</td>
<td>60000</td>
<td>60000</td>
<td>60000</td>
<td>100</td>
</tr>
</tbody>
</table>
Zone 2 displays a higher diversity of livestock species, as ducks, trouts and rabbits were only kept in zone 2.

To properly structure the herd combinations of the farmers and see what species farmers kept together, Table 9 shows livestock keepers and their herd combinations distributed in zones 1 and 2.

Table 9. Categories of livestock keepers and livestock combinations

<table>
<thead>
<tr>
<th>Livestock combinations</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keepers of ll, al, sh, ca</td>
<td>5</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Keepers of ll, al, sh</td>
<td>11</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>Keepers of ll, al</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Keepers of ll, al, ca</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Keepers of ll, ca</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Keepers of ll, sh, ca</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Keepers of al, sh</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Keepers of al, ca</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Keepers of al, sh, ca</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>All farmers (n)</td>
<td>22</td>
<td>24</td>
<td>46</td>
</tr>
</tbody>
</table>

The combinations of livestock species were very diverse, with an emphasis on either all four main livestock species or SACs and sheep. All other combinations are less common.

6.2.2 Perceived developments of livestock numbers in past and reasons for changes

Now that the current livestock status is described, the perceived developments of livestock numbers of the last 5 or 10 years are illustrated. The developments refer to the farm level and represent individual changes. To better understand the displayed results, reasons for either declines or increases of livestock numbers were inquired.

Llamas

The development of llama herd sizes in both zones (Fig. 2) does not give a clear general idea. Less than half of llama keepers (40.5%; n=42) said that llama herd sizes have been increasing on their farm in the last 5 years, 16.7% people said that the numbers of individuals stayed stable and 45.2% of farmers said that the trend of herd size numbers was declining. A slight trend towards a declining number of llamas in the last 5 to 10 years can be observed.

In zone 1, the llama population either increased (30%), was stable (40%) or decreased (30%). In zone two almost half of the farmers either increased or decreased their herd numbers.

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8 Li means llama, al means alpaca, sh means sheep and ca means cattle
Figure 9: Perceived development of llama herd sizes in the last 5 to 10 years, n=42

Reasons for an augmentation of the llama numbers were mostly of economic benefits because of low input costs (mentioned by 20% of interviewed people, n=42). Other reasons were setting up/formation of a new household (so new animals were acquired), llamas were seen as stronger and more robust than other animals, llamas were given as a donation, llamas were successfully exhibited at livestock fairs (and gave an incentive to further proceed with llama breeding), or llamas were seen as easy to manage. One person said that on their farm they have more llamas now as before as they didn’t know how to keep them, but got the knowledge with time. Another person answered that the reason for an increase in llamas was that their llamas simply had foals (without specifying any details).

Main reasons for a decline in animal numbers were mainly either due to a lack of pasture or due to low economic benefits (19% each). Another common response was a decline in llamas in order to enhance the animal’s quality. Further reasons given were breakout of diseases, lack of water, llamas were experienced as difficult to keep, or the decline of llamas was a consequence of negative environmental effects due to climate change.

Alpacas

In alpacas (Fig. 3) an upwards trend in the number of animals could be seen in both zones for the last 5 to 10 years period. Two thirds (66%, n=44) of people said that the trend has been increasing, 16% people said that the numbers stayed stable and also 16% people said that the herd sizes were declining. In zone 1 a higher increase can be seen than in zone 2.
Reasons for an augmentation of the alpaca numbers were mostly of economic nature because of good fibre prices (more than 40% of farmers mentioned this cause). Less frequent reasons were the setting up/formation of a new household (so new animals were acquired), alpacas were seen as being more resistant towards harsh environmental conditions than other animals, alpacas were given as a donation, alpacas were easy to manage. Some farmers gave the answer that their alpacas simply had foals, one person said that they have more alpacas now as before they didn’t know how to keep them, but got the knowledge with time.

Similar as for llamas, reasons for a decline in alpaca herd sizes were mostly due to a lack of pasture or lower economic benefits than expected. Other explanations were an improvement of the animal’s quality (so the weak or the ones that did not fit the breeder’s goal were disposed of), a breakout of diseases, lack of water, consequence of climate change, and lack of time.

**Sheep**

Sheep population (Fig. 4) shows a decreasing development (62.5%, n=40). Increases of sheep numbers were reported by 15% of farmers and stable numbers by 22.5%. Sheep numbers indicate a decline in both study zones.
Reasons for an augmentation of the sheep numbers were: setting up/formation of a new household (so new animals were acquired), economic benefits, sheep were easy to handle/manage, and one farmer answered that the sheep simply had lambs, without giving further specifications.

Main reasons for decline were unfulfilled economic expectations stated by 32.5% of all interviewed sheep keepers, and a lack of pasture (22.5%). Other explanations, similar to the ones before, were a decline in numbers in order to improve the animal’s quality, an outbreak of diseases, sheep were exchanged for alpacas (because of expected higher incomes with alpacas), a lack of water or time, a reduction due to negative consequences of climate change, and sheep were seen as hard to handle/manage.

**Cattle**

The development for cattle (Fig. 5) was rather stable than decreasing in the last years. 17% (n=24) of farmers said that the herd sizes have been increasing in the last 5 years, a bit more than the half of all interviewed cattle keepers (54%) said that the size stayed stable and more than a third (37.5%) of farmers said that their herd size was declining.
Reasons for an augmentation in the cattle numbers were expected economic benefits through milk sale and a general lower mortality than before.

Reasons for decline were due to a lack of natural resources (pasture and water), a decline in numbers in order to enhance the animal’s quality, management difficulties, or lack of time.

6.2.3 Expected developments of livestock numbers in the future and given explanations

To get an idea about general developments, not only past trends are necessary to see and understand, also anticipated future prospects need to be considered. Thus, farmers were asked about their ideas and plans for the future development for their main livestock herd sizes and the reasons for either augmentation or decline. The development refers to the farm level and represents individual answers. Also farmers who currently do not keep all types of livestock were asked if they consider keeping the absent livestock type in the future.

Llamas

Starting again with llamas, the majority (68%) of farmers wanted to increase their llama numbers (or keep them in the future if they did not keep them at the time of the interview), and 32% answered that they do not want to increase (or not keep them in the future either). Figure 6 points out the results for the two zones.
Reasons for planned increase were mostly due to expected economic benefits. Other advantages recognized were llamas being more resistant than other livestock, their meat was healthier (compared to sheep and cattle), they were easier to handle, or to rise their production for own consumption, or to use them for sale of breeding animals.

Reasons for not increasing llama numbers in the future were because expected economic benefits did not come true or because of a lack of resources (pasture, water, or summed up as negative consequences of climatic variability).

![Figure 13: Expected development of llama herd sizes in the future](image)

**Alpacas**

More than half of the interviewed people (53%, n=46) planned to rise the alpaca number (or keep them in the future if they did not have them at the time of the interview), almost the other half of the farmers (47%) did not want to increase (or not keep them in the future either). Figure 7 shows the results for the two zones.

Reasons for augmentation were again anticipated economic benefits, or recognized advantages of alpacas being more resistant than other livestock, and as a source of healthier meat (compared to sheep and cattle).

Reasons for not augmenting the alpaca numbers in the future were again due to unmet economic expectations or a lack of natural resources as pasture and water. A few farmers said that they
wanted to improve the animal’s quality (and therefore need to select the appropriate ones), and few other farmers claimed that alpacas were not resistant and strong enough to handle the changing environmental conditions in the long term.

![Graph showing expected development of alpaca herd sizes in the future](image)

**Figure 14: Expected development of alpaca herd sizes in the future**

**Sheep**

Sheep herd sizes also seem to be declining in the future. About a third of the interviewed farmers (34%) planned to increase their sheep numbers (or keep them in the future if they did not have them before), the other two thirds (66%) did not want to augment (or not keep them in the future either). Figure 8 indicates the results for the two zones (where almost no differences can be seen).

Reasons for augmentation of sheep numbers were anticipated economic benefits, or sheep were seen as easier to handle and their manure as a source of good fertilizer. Reasons for not enlarging herd sizes were again due to unfulfilled economic expectations, a lack of natural resources, harder handling of sheep compared to other livestock, less resistance to diseases or to improve the sheep’s quality (by selecting the promising ones).
Cattle

Almost half of the interviewed people (44.7%) wanted to augment their number (or keep them in the future if they did not have them at the time of the interview), and a bit more than the other half (55.3%) planned to decrease (or not keep them in the future either). Reasons for augmentation were economic benefits expected by selling more milk. Figure 9 points out the details for the two research zones.

Frequently mentioned reasons for decreasing the cattle number were because of lack of pasture. Some farmers said that they never had cattle (and therefore did not know how to manage them), one person wanted to improve the animal’s quality and not the quantity.
6.2.4 Livestock comparisons – advantages and disadvantages

Tables 8 and 9 illustrate the view farmers have on their own livestock in terms of attributes and characteristic traits. This comparison was thought of being done as a ranking between llamas, alpacas and sheep, but not all farmers could clearly distinguish between all inquired aspects of their livestock. So in the end this comparison was rather conducted as a rating and only with farmers who actually keep the mentioned livestock species (alpacas, llamas and sheep). Farmers who only keep one or two of the three species were not requested to participate in this comparison.

Table 10 highlights that llamas are mostly seen as tolerant towards natural conditions as cold, high altitude, drought, poor forage quality, disease susceptibility and easier handling. But when it comes to markets, sheep and alpacas are seen to get better values. In reproduction there was mostly no difference between the species, and sheep have a slightly better reproduction rate than alpacas or llamas.
To get further details about advantages of some livestock types compared to the others, the interviewed farmers were asked detailed questions about environmental and economic aspects of their livestock. Apart from gaining more information, the validity of the answers that were given in the table before was checked (Table 11).

### Table 11. Farmers’ perception about requirements of different livestock species

<table>
<thead>
<tr>
<th>Species</th>
<th>Low water requirement</th>
<th>Low feed requirement</th>
<th>Degrades soil</th>
<th>Highest costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpaca</td>
<td>11</td>
<td>40.0</td>
<td>3.8</td>
<td>54.5</td>
</tr>
<tr>
<td>Llama</td>
<td>67</td>
<td>24.4</td>
<td>7.7</td>
<td>0</td>
</tr>
<tr>
<td>Sheep</td>
<td>2</td>
<td>17.8</td>
<td>88.5</td>
<td>36.4</td>
</tr>
<tr>
<td>Alpaca and sheep</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Llama and sheep</td>
<td>0</td>
<td>2.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Llama and alpaca</td>
<td>2</td>
<td>6.7</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>No difference</td>
<td>18</td>
<td>8.9</td>
<td>0</td>
<td>6.8</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The majority of the people (67%) said that llamas needed to drink less water than the other livestock types, and alpacas needed less feed (for 40% of the inquired farmers). If grazing behaviour leads to soil erosion was asked as well, and most farmers (88.5%) agreed that sheep erode the soil more than SACs. As the most expensive animal considering maintenance, veterinary services and infrastructure was the alpaca mentioned by 54.5% of farmers.

### 6.2.5 Production strategies - specialization or diversification

To get a deeper understanding of the socio-economic significance of livestock production, the chosen production strategy was investigated. As already mentioned, all farmers kept two to four species of main

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9 No difference refers to the farmers who could not tell a difference between the three livestock species. Numbers in percentage.

10 Compared to other species. Numbers in percentage.
livestock and most of them also kept other livestock. In general, 15% of farmers (n=46) said that they preferred to just keep one main livestock species, the other 85% said that they preferred to keep two species or more at once. Diversification seems to be the norm. Nevertheless, the current specialization-aspect was analysed. Specialization here means that the farmers were asked if they earned more than 75% of their income with just one main livestock species. According to this definition, about 25% consider themselves in their own perception as specialized and the other 75% of farmers consider themselves as diversified. Variations of these production strategies could be seen in the different zones (Fig. 10), with a slightly higher specialization in zone 1.

![Production strategy of farmers](image)

**Figure 17: Production strategy of farmers**

### 6.2.6 Reasons for diversification or specialization and its advantages and disadvantages

All farmers, the specialized ones and the diversified ones, were asked to give advantages and disadvantages of both production strategies. Almost half of the farmers did not know any reason for specialization and did not give an answer.

The principal reason for a current diversification was an improvement of income, as keeping various types of livestock broadens the range of products that can be offered and sold (45%). Other reasons were continuing the tradition of keeping various species at once, better usage of pasture (as different species prefer to graze at various spots and plants) and, to a lower extent, a wider range of products for auto-consumption.
As reasons for current specialization were mentioned higher earnings by one type of livestock (usually alpaca), as more effort and focus can be put on one species. Some farmers noted that it was more work intense to have more species with differing requirements; pasture was not enough to keep several species together, or one species was weaker and therefore needed more attention.

The specialized farmers were mostly specialized in alpacas and to a minor extent in sheep or llama.

Farmers who said that they wanted to specialize their production in the future, mostly planned to specialize in alpacas or llamas. Other options mentioned were sheep, cattle, alpaca and sheep together, both llama and alpaca, llama and cattle, both sheep and cattle, or other species as guinea pigs or trouts. Principal reason that were brought up for a possible future specialization were mostly to earn a higher income, or because of a higher resistance to diseases and climate variability. One farmer said that he wanted to change the livestock type to a less labour-intensive one (from sheep to llama).

Smallholders, no matter if they saw themselves as diversified or specialized, were asked for possible advantages of diversification. Answers given were mostly of market-oriented nature, as most farmers believed in more market options by selling a broader product range from several species. Other, fewer mentioned reasons for diversification were a better use pasture with mixed herding (because of different grazing preferences), similar management of different livestock types, having a lower economic risk in case a species got sick, or going conform with tradition. Brought up disadvantages of diversification were also miscellaneous. It should be noted here that only a bit more than half of the respondents gave reasons here as the other half did not think of any disadvantages. Most farmers said that keeping various species was more work intensive. Others feared overgrazing or higher costs of keeping many species at once, and also a greater risk to spread diseases. Others mentioned that more knowledge and skills were necessary to keep various species at once.

### 6.3 Natural resources and climate change

#### 6.3.1 Natural resources – pasture and water

For successful animal husbandry, a good quality of both pasture and water resources are critical to maintain and have access to. To assess the status quo of the farms concerning these resources, the farmers gave answers about their perception of their natural resources and how the state of the natural resources developed in the last 5 years. Another inquired aspect was if climate change was perceived as a problem. Potential negative consequences of climate change on livestock and how farmers adapted and coped with climate change consequences were investigated as well.
Pasture quality

Of all interviewed farmers, half of them stated that their pasture condition was improving within the last 5 years, about 10% said that it stayed equal, and 40% said that it got worse. There was a big difference between the two zones. In zone 1, about 23% said that their pasture quality was improving, 18% said that it was equal to the last years and 60% said that it was getting worse. In zone 2, 75% said that pasture quality was improving, 4% said that it stayed equal and 21% said that it was getting worse (Fig. 11).

![Figure 18: Trend of natural resources - pasture quality in different zones](image)

Reasons for pasture improvement in the last years were making use of the improvement techniques of sown pasture and rotating pasture. Mentioned reasons for pasture deterioration were mainly due to a lack of water or because of unfavourable weather conditions and climate change. Also overgrazing was stated, and one farmer blamed his sickness that left him unable to take care of the pasture.

Water availability

Water availability and reliability are besides pasture quality crucial for livestock keeping. So to assess the sustainability of the farmer’s livelihoods, also the water aspect was covered in the questionnaire. Results indicate that a bit more than 75% of farmers claimed that they did not have enough access to water on their lands (Fig. 12). Consequently, less than 25% were satisfied with the water supply for their livestock. In zone 1, 4.5% of the farmers said that there was sufficient water available the whole year round, whereas in zone
2, 42% said so. In zone 1 therefore 95.5% said that there was not sufficient water, in zone 2 only 58% said so. Asking for the development of water resources within the last years, no one affirmed that there was a trend towards more water available for them. Consequently, half of the farmers in both zones perceived stable conditions and the other half said that water resources are declining.

![Water availability chart](image)

**Figure 19: Development of natural resources - water availability in different zones**

### 6.3.2 Climate change

All interviewed farmers noticed changes in the climate. When asked for the exact changes on the weather, a broad range of answers was given. Multiple answers were possible. So 63% mentioned noticeable changes of the seasons (rain during dry season, less or no rain during wet season), 33% less rain (over the whole year) and 33% more rain within the last 5 to 10 years. As well 33% mentioned higher temperatures and 76% lower temperatures (some people noticed both changes at the same time). 65% noticed more freezing and snow and 7% observed the opposite. 9% observed more or stronger wind and more than half of the interviewees said that the pasture was affected negatively by the weather conditions. In this last point there was a noticeable difference between zone 1 and 2: In zone 1, 82% complained about climate change negatively affecting pasture quality, whereas in zone 2 only 29% did so.
6.3.3 Climate change related effects on livestock and how farmers cope with them

Does the changing climate have consequences for their livestock? Practically all farmers (98%) observed more diseases in their livestock and linked these observations with climate change. Almost as many (83%) noticed a higher mortality. 87% claimed that the production was negatively affected. One farmer noticed dark pigments on the skin of his alpacas (due to a possible higher radiation). Other effects noticed were general unfavourable environmental conditions and a lack of water. Interestingly, one person claimed that the types of livestock kept in the area are simply not adapted to the harsh environment and consequently most of the health problems occur.

To adapt to the negative consequences of climate change, some farmers (60%) applied strategies to cope with climate change and to decrease morbidity and mortality of their livestock. Adaptation strategies against the effects of climate change were: shelters for protection (43% of farmers applying strategies mentioned that), administration of medication or vitamins (17%), more drinking troughs (4%), usage of sown pasture (7%), blankets for animals to keep them warm (4%) and trees or other constructions as wind protection (4%).

6.4 Future perspectives and developments on farms

As written in the literature and described in the results, the farmers in the research villages face various economic and ecologic constraints that, on the long or even on the short term, might cause emigration. Especially climate change and, for some interviewees, an unsatisfying economic situation might lead to changes of their livelihoods. This is reflected in the anticipated change of livestock species kept in the future. Also the already mentioned fact that most farmer’s children do not live in the study area and do not work in the animal husbandry sector as a profession should be of concern.

Therefore to assess future developments the farmers were asked if they wanted to change their income source (on-farm or off-farm) and/or undertake improvements of their animal production. Further, as the regions face emigration and farm abandonment it was interesting to me to find out if this is also something the interviewed smallholders think of. So they were asked under which circumstances they might consider leaving their farms, and what needs to be done to make them stay and work in animal husbandry.

6.4.1 Planned changes of income sources and farm improvements

Of all interviewed farmers, a bit more than 75% planned to change their income source. Of those, 26% (n=35) wanted to invest more in their farms or switch to other, more promising livestock species to enhance production. The other 74% wished to work in non-farm activities. Those wanting to work outside their farm (or want to intensify the time they work non-farm and the income they get if they already engage in non-farm activities; n=24) gave a very broad spectrum of possible employment opportunities. Almost a third of farmers would like to set up a business. Other farmers wanted to work in construction, in extension service,
doing and selling handicrafts on markets, carry out occasional jobs, work as a teacher, doing welding, politics, agricultural processing, work in the mining industry or as a herder. The reasons for that were basically to raise their income. Two farmers wanted to improve the environment and act against climate change (by planting trees that should also be sold), one wanted to change actual politics and one said that businesses were needed in the area.

Apart from the financial aspect, most farmers had ideas for improvements and changes related to livestock production for the future. Most necessary to them seemed to be the enhancement of the genetics of their animals (about 85%). One quarter said that they planned to seed pasture in order to improve the pasture’s quality. Other changes named that are expected to improve the income were the acquisition of better breeding animals or more cattle for a higher milk production, or to rise the number of SACs, or to start to use artificial insemination for cattle.

6.4.2 The possibility of emigration
Bearing in mind the economic challenges of the research villages, still most farmers did not want to change their livelihood strategy and wanted to keep on living and working on their farms. About a fourth could imagine leaving their farms due to economic hardship and stop working in animal husbandry. Their reasons for this potential emigration are linked to poor livestock productivity leading to poor income, or limited access to markets. Poor pasture quality and health problems of one of the respondents were other causes. Farmers living only from on-farm income are rather more prone to stay, only 20% of them could imagine migrating. Considering these results, only 11 farmers out of 46, representing 24%, can be regarded as satisfied with their economic situation, meaning that they only work on-farm, do not plan to diversify their livelihood strategy via non-farm income and also did not think about migrating to other places.

But when asking this question related to the effects and consequences of climate change, more farmers (35%) said that they would consider leaving animal husbandry, if climatic conditions got worse. In zone 1, about 25% of farmers said that they would leave animal husbandry, whereas in zone 2, about 46% said so. Farmers living only from on-farm income do not differ in their answer, also 35% would leave. The other 65% would stay, even if climate got even more variable.

6.4.3 Personal wishes for the future - how to make farmers stay?
In the last question, farmers mentioned their hopes and wishes for the future. Most topics raised were linked to conditions and tool that could enable them to enhance their livestock production. The most commonly mentioned necessity was getting more support from the regional governments or other external institutions (about 80% of farmers). Getting a better extension service was wished by half of the farmers, right followed by a better infrastructure and better access to technologies, machines and tools. Less
frequently named were access to cheaper medicaments and supplements, better market access, more investigation and research about alpacas, and each one farmer wanted to have more time for his farm, wished to have a better production, wished less middlemen in the value chain, more access to credits, better housing conditions, to set up a small company and a good future for their children.

7. Discussion

The data collected in the case study and represented here are all own perceptions of the interviewed farmers. No crosschecking of data could be realized, so the results have to be handled with caution. Still, useful and interesting information of the current livelihood, production strategies and income-generation and their limitations and restrictions are shown. Parts of the discussion also come from my personal perceptions and observations of the case study area, which might have been seen differently by other researchers.

7.1 Major findings of the case study

In the Andes the environment and climate, how markets function, and the political environment are factors that create uncertainty (Valdivia 2004). Diversification of the household’s set of activities is the expression of this uncertainty. Risk management, coping with shocks, and resource use maximization explain the diversification observed in the Andean region (Darnhofer 2010; Valdivia et al. 1996). In areas of greater risk, household strategies are expected to be more diversified as a means to minimize possible shocks from negative climate events, especially when management strategies are limited (Valdivia 2004 and references therein).

The results confirm that smallholder farmers in the Pasco and Daniel Carrión provinces face multiple stresses and increasing threats to their livelihoods. These stresses as drivers of agro-ecological and socio-economic change can be assigned into two key categories. First, there are ecological challenges as poor natural resources and overgrazing, climate change and poor animal health, leading to an overall decrease in animal productivity. Second, there are economic challenges, as a declining income by animal husbandry, volatile market prices and the increasing need to work off-farm. These stresses and threats, if not mitigated, in some cases will lead to an alteration in the farmer’s livelihood strategy. In the long term, farm abandonment due to temporal or permanent migration to urban areas motivated by the hope of better lives, in itself a part of livelihood diversification, might happen.

Phrased differently, one of the main processes of livelihood change in this case study area is the loss of the ability to financially survive with farm income alone. This leads to the gradual adaptation to a new livelihood
and a new professional strategy (Kristjanson et al. 2007). This especially concerns the young generation. It can be assumed that young people prefer to pursue a different income-generating strategy than making a living from livestock production under harsh conditions. This is affirmed in the results, as most of the farmer’s children do not live in the area and do not work in animal husbandry anymore. This phenomenon is also reflected in the high age of my interview partners (45.4 years on average). The question of who will maintain the farms in the future arises. Especially working in mining operations seems to be attractive for young male farmers (although no one did so of the interviewed farmers), as the salary is much higher and stable throughout the year (Flores 2013; Palomino 2013). This in turn will lead to a continual loss of population that reduces the size of the communities and, makes it even harder for farmers in the region to claim support from governmental and agricultural authorities.

7.2 The role of women

Traditional gender roles persist, as women are mainly responsible for household work and men have a (slightly) better education level as women. This explains my experienced challenges when interviewing women. Wolfinger (2012) found that women often responded that their husbands would be able to answer the questions more precisely, which was also my experience. Some of them had very little information about the household’s production system and could not give precise livestock numbers or other details about livestock keeping. Some women seemed unfocused and distracted. Also some male interview partners did, but to less extent. As women having lower education levels (IFAD 2013) and less awareness and information about the applied production system, less decisions can be made by them, meaning an actual loss of human resources as a consequence. Still an improvement in education levels was visible (Gobierno Regional de Pasco 2010), probably because of literacy programs focussed in the area.

It also seemed that non-farm employment to a big extent was rather reserved for men than for women, as women, especially when having small children, were the ones that tend to stay at home. Non-farm activities as working in mines, construction and transport are frequently gender specific and seen as a job for men and not for women, and women were, in my point of view, limited to low-wage activities in the non-farm sector. Of course women also worked outside the farm, but not as much as men did. This phenomenon was also observed and described by other authors in other parts of the world (Kabeer 1990, as cited in Hussein & Nelson 1998; Reardon 1997). Some male farmers also answered that their wives did not work, only when I asked them if they did not engage in livestock keeping activities at all, they realized that their wives did actually work and take part in livestock production. Also most farmers stated that they still had enough time for their animals, even when working off-farm every day. This gives the impression that women and other people staying at home made this possible by getting more involved into animal production. Also Valdivia
(2000) confirms that women get more responsibilities and decision power when husbands work non-farm or migrate.

Observation of other authors about women being responsible for livestock (Budak et al. 2005; Valdivia et al. 2004; van’t Hooft 2002) cannot be confirmed by my experience. Women being responsible for livestock might apply if the husband works off-farm, and under this condition a woman complained about the difficulties she experienced handling cattle. The impression rather arose that women were responsible for smaller livestock as chickens and guinea pigs and men, if available, for large livestock. Valdivia (2000) also expressed this observation for similar studies conducted in Peru and Bolivia. Gender and resource management research found that women are in charge of sheep (and other smaller livestock). Cattle and dairy production were rather the domain of men.

To deeper discuss these and other findings, the research questions will be answered in the following sections.

7.3 What are the characteristics of the chosen income-generation and production systems?

Wii (2013) argues that despite a high annual growth in the national economy over the past decade, Peruvian highland farmers have remained poor. Lack of resources and assets is omnipresent and also expressed in official data about the case study area (Pasco Regional Government 2010). Generally in the Andes, livestock husbandry is one of the main economic activities (Valdivia et al. 2013) and the commonly found livestock production system in the study region is a low-input low-output system (Wurzinger et al. 2013). Many people of the research villages work in livestock production, although with a declining trend, and migration to urban areas is common (IFAD 2013).

As main life goals, farmers in the high Andes want to maximise animal and economic performance, avoid economic and environmental risks, mitigate effects of climate change and improve their living conditions (Valdivia 1996). In order to achieve their goals, the interviewed farmers showed a diverse range of livelihood and production strategies. These strategies can be, in case they do not prove successful, changed for other strategies (van’t Hooft 2002). In most cases, a high flexibility towards changing conditions was observed. More than half of the farmers (56.5%) work in non-farm activities. These activities are very diverse, ranging from construction workers to being researchers at universities. Also the time invested in non-farm activities was different from farmer to farmer, some farmers left their farms every day to work, others just one month in a year and others worked on an irregular base, accepting almost every kind of work that was offered to them.
As the region is known by its mining industry (Pasco Regional Government 2010), it was expected to also find and interview farmers who worked in mines. But it seems that working in mining operations is more common in other districts (i.e. in Huayllay) and not so much in the researched ones. Also in some cases, as mine workers have shifts of ten days to two weeks, where they stay close to the mines, they were not available for interviews at the time the interviews were conducted. One farmer reported that he used to work in mines, but then set up his own business.

Similarities were tried to find for the livelihood and production strategies of farmers and their distribution of resources. Very few characteristics, as the high diversification level and an increasing desire to adopt a different professional strategy, can be seen as common grounds of the farmers. The numbers and combinations of livestock species do not show similarities, probably due to different endowments of the farms, family traditions, and experiences and expectations regarding market developments of livestock products.

This is in accordance with findings of Kristjanson et al. (2007) and Valdivia et al. (1996), who highlighted the importance of economic diversification for Andean peasant households of crop/livestock production and wage labour. Improved and traditional livestock and crops are being used at the same time. The aim is to smooth both predictable and unpredictable income fluctuations.

Under these unstable conditions farmers in the case study region face, farm management to keep production successful has become increasingly difficult. Encompassing economic, environmental, climatical and to some extent social aspects at the same time is needed for a successful farm management (Mugnier et al. 2012). Especially a proper management considering natural resources is necessary, as also smallholder farms create degradation in their environment (Hazell et al. 2010). Nunes et al. (2013) highlight that farmers might underestimate the power of environmental management for reducing future costs, increasing efficiency and for achieving long term benefits such as soil conservation and a greater level of sustainability in the region. The authors also found in their case study that there is a connection between the education of farmers and the perception of environmental issues. This highlights the importance of capacity building, extension services and environmental education also for the case study area, as these were also desired by the farmers.

7.3.1 Why do some farmers diversify their economic activities to non-farm income and why do others specialize in animal husbandry?

Diversification in general can be seen as a common means to achieve sustainable livelihoods (Escobar 2001; Hazell et al. 2010; Reardon 2001). But how is diversification of livelihood strategies implemented in the case study area? Less than half of the farmers (43.5%, n=46) got their household income only from animal
husbandry, and the importance of non-farm income was rising for at least 13% of the households within the last years. So the need to work off-farm and to diversify the farmer’s livelihood via non-livestock means was high, as income through livestock production declined over the last years and market prices for livestock products changed unfavourably in the study area. When farmers were asked what type of non-farm activity they would like to carry out, a range of different options was given deliberately, showing that the farmer’s answers for possible job opportunities were well considered.

Even elderly people were hoping to get the option to diversify their income in the near future. Elderly people and families with young children expressed their despair of sinking deeper into poverty if conditions got worse, indicating a rather precarious economic situation at present.

The possibilities to work outside the farms might also not always be given to everybody who needs it (Reardon 1997). The nearest urban centre is the capital of the Pasco region, Cerro de Pasco, where economy and population are growing due to ever increasing mining industry. But means of transport, education and skills, gender and age appear to be strongly related to the pursuit of better income generating activities in the non-farm sector and thus can be seen as limiting factors (Canagarajah et al. 2001).

These limiting factors might be reasons for non-diversification of income, as 20 farmers (43.5%) out of 46 do not diversify their income and only live from the livestock sector on their farm. Of those 20 farmers who fully work on-farm, 40% planned to diversify their economy via non-livestock means in the future. For the other 60% that did not state to have economic diversification plans outside their farms (but four farmers planned to invest on-farm), satisfaction with their present lifestyle can be assumed. Only one of the farmers who fully worked on-farm and can be seen as satisfied with the household’s income (meaning that he did not show plans to diversify to non-livestock activities) would abandon the farm and migrate because of economic reasons. Three more of those farmers, who only worked in livestock activities and planned to diversify in the future, would do so.

These findings affirm that farmers diversify to non-farm employment, because they simply have the economic need to do so (Haggblade et al. 2010; HLPE 2013). Also in some cases non-farm employment can be seen as a strategy that detains farmers from abandoning their farms. Motivations for economic diversification always deal with a higher and more reliable income that can be achieved with only livestock-related activities, and, in the end, to spread the financial risk and become more resilient to economic stresses (Darnhofer 2010, Valdivia 1996). Also the wide range of possible activities (due to the heterogeneity of the non-farm sector), as working in mining industry, construction, business, or transport was seen as a motive that facilitates diversification.
These results are in line with the findings in the literature. Authors, as Haggblade et al. (2010) and Hussein & Nelson (1998; and references therein) have approved that diversification is very common for rural people all over the world. Rather, the majority of rural producers have historically diversified their professional activities to encompass a range of other productive areas. Jimenez Sardon already observed in 1984 in Bolivia that smallholders in rural Bolivian communities developed mixed systems, in which the production of crops and animals are combined with income-generating non-farm activities. The strategies vary a great deal from one family to another, and also within a family, depending on the time of the year, the age of the family members, or external circumstances. It has been calculated that 90% of rural families in central and south Bolivia earn more than 50% of their income through non-agrarian activities. Referring back to the case study area, in the results it can be seen that for 63% of farmers the importance of animal production and non-farm employment for the household’s income stayed the same, showing that economic diversification is not a new phenomenon in the research area either. Also 37% of farmers reported that they worked nowadays the same time in non-farm employment as they used to do 5 to 10 years ago. A third of the farmers or their household members also reduced the time working non-farm within the last years. This could be explained by the advanced age of the farmers, as some farmers were already retired.

7.3.1.1. Is diversification to non-farm activities the solution?

As written in the literature section, non-farm activities are seen as a mixed blessing with both advantages and disadvantages for farmers, depending on various factors. As only a few farmers in the Pasco region do earn their whole income from livestock-related activities and do not consider diversifying their economy due to financial reasons, it can be assumed that non-farm activities are simply necessary for farmers to survive. Without non-farm activities farmers would even be resource-poorer as they already were or would migrate to urban centres or other departments.

Kristjanson et al. (2007) found in their study about poverty dynamics and the role of livestock in the Peruvian Andes that in Cajamarca, a northern department of Peru, fifty-nine percent of households that had escaped poverty mentioned income from non-farm diversification as an important factor. The percentage of households that had escaped poverty mentioning livestock-related diversification strategies was 57%. Mostly improving the livestock’s genetic proved efficient in escaping poverty.

The coordination of livestock production with non-farm activities, as farmers move to Cerro de Pasco, mines or other places to work, involves challenges. Conflicting demands for labour and time are likely to appear (Darnhofer 2010). The (usually) male farmer and his labour might be missing on the farm. Hence large numbers of animals and pastures need to be managed by less working units, usually by women, children and old people remaining on farms. This on the long term can lead to smaller herd sizes and a decline of animal
husbandry in the area. Harmonization of on-and non-farm activities should be the goal to mitigate disadvantages, but seems to be difficult under practical conditions.

In the end, under special conditions, non-farm activity can be seen as a means of increasing resilience of farms. In addition the option to work non-farm decreases the need to abandon the farm and migrate. But also other conditions need to be improved and implemented to make farmers stay. Naupari and Ruiz (personal communication) argued in the expert interviews, that farmers should cooperate and organize themselves to represent the interests of their vulnerable rural communities. Also governmental authorities need to give support with social and economic programs. Capacity levels are poor (Palomino 2013), so extension services need to be offered. Other suggestions by the expert interview partners were a better accessibility of markets, improvements of natural pasture and animal’s genetics.

Similar to the conclusion of Darnhofer (2010) the appropriate mix of livelihood and production strategies depends on a range of situational factors. Some of them can be influenced by the farmers themselves, as the right choice of the livestock species, conservation of natural resources, adaptation to climate change or acquired capacities for non-farm jobs; and others cannot be influenced, such as external processes between the farm and its environment, opportunities that arise, economic, political and market situations, climatic conditions and so on.

7.3.2 Why do some farmers specialize in one type of livestock and why do others diversify their livestock?

As described in the section above already, farmers see their future as unpredictable, facing external changes they cannot influence but need to adapt to (Darnhofer 2010). This situation is also expressed in the results concerning the chosen production strategy. No farmer only kept one type of livestock. Most farmers kept three or four main livestock types. In addition, most farmers (87%) also kept other livestock species as chicken, guinea pigs, rabbits and others, usually in small numbers. This shows a high degree of livestock diversification. This is in accordance with findings of van’t Hooft (2002) for similar ecosystems in Bolivia, where farmers also keep poultry, guinea pigs, sheep, goats, pigs, cows, donkeys, llamas, alpacas and rabbits, and sometimes, depending on ecological circumstances, carp and bees. Also Ellis & Mason (1999) also found a diverse array of livestock in their study in the Andes.

As mentioned before, no clear trend can be seen between the decision of what main livestock species and how many of them are kept and the engagement in non-farm activities. This again indicates the broad distinctions and differences among the applied strategies. Even farmers being neighbours or family members diversify in different ways and common grounds are hard to find in this vast number of livestock species kept as a part of their livelihood.
Different livestock keeping strategies can be observed among rural families. Basic elements of these strategies are, as mentioned above, the husbandry of various animal species, the flexibility to change from one species to the other, and the low-external-input nature of the management system. Most families base their livestock keeping on diversified husbandry practices (Van’t Hooft 2002).

In order to find out about this diversification aspect and the applied production strategies, challenges were encountered when directly asking for the degree of specialization, as explained in the methodology. This led to a discrepancy of farmers saying they were specialized and their actual number of species and individuals showed the opposite. In the interview a bit less than a fourth of farmers said that they were specialized according to the definition of earning 75% of livestock from one species. This species in most cases was the alpaca. But when crosschecking the data of their livestock species and numbers, this does not seem to be possible in every case. In about a fourth of the so called specialized farmers (3 out of 12) livestock species and numbers seem to be variable. As no verification of the data could be done by looking at the prices of livestock products, this information needs to be handled with caution.

Regarding the actual livestock numbers, a new definition was created: Farmers keeping only two main livestock species were considered as specialized. As indicated in the results, this new group only comprises of five farmers. To see if this group shows some noticeable characteristics, an attempt to describe them by their levels of non-farm activities was done: These few farmers who keep only two types of main livestock have different levels of non-farm activities. Interestingly two farmers having several hundred main livestock numbers engage in jobs outside their farms and do not keep other livestock (chickens, guinea pigs, rabbits or others). The other three having lower numbers of main livestock work only in livestock husbandry and also keep other livestock species. This means that only two out of 46 interviewed farmers can be described as specialized according to the new definition. The other 41 farmers were diversified in their production strategy to varying degrees. With such a little number of specialized farmers, no correlations can be found that might explain a broader common production strategy of the research villages. This leads to the already mentioned conclusion that diversification is the norm. Van’t Hooft (2002) explains this high livestock diversification also by the fact that animal husbandry is embedded in ancient Andean cultural values, such as solidarity and reciprocity, and respect for Pachamama –Mother Earth. Rural families perform numerous rituals and festivals related to livestock throughout the agricultural cycle. As already delineated in the results, livestock play many different roles for the interviewed farmers as well, and this can be, apart from environmental and economic fluctuating conditions, another explanation why a wide array of livestock are kept in the case study area.
The given reasons and advantages for diversification were mainly linked to a broader range of products that can be sold, better market access and an increased resilience towards external shocks (Van’t Hooft 2002). The capital city Cerro de Pasco is easily accessible within one hour driving distance from most farms. The area also lies in a strategic good position on the road from Lima (6 to 7 hours) to the lowlands (selva), meaning goods get transported quickly. The unstable and unpredictable price developments make it necessary for farmers to lower vulnerability by preventing economic losses due to unexpected price changes of livestock products (Castellanos et al. 2013; Darnhofer 2010). As explained in the results the effects of climatic variability lead to unstable environmental conditions and losses of livestock productivity, so also under this condition diversification definitely pays off more. This is also expressed by the fact that only 15% of farmers see, in the long term, more economic sense in specializing their production system to only one species. Still, more than half of the farmers were considering focussing more on one or two species to some extent, leaving behind the definitions of specialization here. The main species that were named to focus to in the future were llamas and alpacas, reflecting the market opportunities or environmental adaptations these species offer to the farmers.

The question for reasons for specialization was answered by less than half of the farmers, indicating that the concept of specialization itself might not be very well-known in the area. In specialization, livestock usually only fulfils the purpose of cash income. The reasons for specialization given were mostly related to less work in the husbandry of only one species. Van’t Hooft (2002) underlines this and also found that in specialized systems mortality of animals is low, as animals receive extra attention due to high individual value of the animal and the specialized knowledge and network required. Also in specialization there is a high dependence on external conditions as markets, diseases and natural resources. If changes of external factors happen, the flexibility of these systems is low.

Van’t Hooft (2002) concludes that most livestock development initiatives have aimed at changing the diversified systems into more specialised ones. But this does not fit into the logic the livestock production is based on and the farmer’s mindset. Optimising the diversified system of family level livestock keeping within its own context is an under-utilised niche for poverty reduction.

Mixed herds were seen to be the most common form of herding, either in the combination of llamas and alpacas (as opposed to the observations of Sumar & Camino 1992), alpacas with sheep, or all three species together. The strategy of herding all species together seems to be efficient in time and space, especially when pasture area or fences are not available. However, in few cases sheep were observed to graze in different areas than llamas and alpacas. An explanation given by a farmer for this separation was that alpacas and sheep are known for competing for the available pasture. To spend the night, the species usually
had different spots, sometimes they were also kept together. Cattle were usually kept apart on cultivated pasture.

7.4. **What is the farmer’s perception of the advantages and disadvantages of each livestock species and of the chosen strategy?**

The farmer’s perceptions of advantages and disadvantages of the major species (llamas, alpacas, sheep and to some extent cattle) and their roles and purposes can be described as following:

**7.4.1 Llamas**

Llamas form a traditional livestock species that has been kept in the area for a long time with the main purpose of carrying agricultural crops to markets. Meat production has also been an important function.

In the literature, llamas are seen to be very robust and persistent, with undemanding and limited needs for pasture, water, health care and attention. They are easier to handle than other livestock species and more resistant to diseases. Llamas are perfectly adapted to the environment they live in, without leading to environmental degradation as soil erosion (Davies et al. 2007; Sponheimer et al. 2003; Van Saun 2008; among others). These findings were also supported by the results of the interviews.

The consciousness that llamas will rather handle the effects of changing environmental conditions was very high among the interviewees. This is also reflected in the results, as almost 70% of farmers want to increase the number of llamas on their farm in the future. Llama keeping is seen as less work-intensive and a resource-saving activity with expected economic benefits on the long term.

Still, the tendency of llama stocks in the last years did not show clear results, but a declining number of llamas in the last 5 to 10 years can be observed. The decline in pasture quality and missing economic benefits are reflected in the reasons given by the farmers, as these aspects were mentioned most.

Llamas have always been used for sale or consumption of fresh or dried meat, sale or domestic use of fibre, transportation, manure as energy source or soil fertilizer or, as some farmers answered, simply kept out of tradition. Maranon & Mariscal (2011) confirm my observations that llama meat was frequently used for auto-consumption and barter trade between neighbours and villages, improving food security. They also highlight the cultural and religious value llamas play in peasant villages.

The big disadvantage of llama keeping is the missing market. This is also reflected in the results displaying the low earnings farmers get from their livestock and the past development of livestock numbers, as many people lowered their llama numbers in the last 5 to 10 years. This might also be the reason for the small herd sizes of llamas.
The low earnings made from llama production have various reasons: Consumers fear sarcocystosis\(^{11}\), what causes considerable income losses to farmers (Rooney et al. 2013), or generally consider llama-meat as “food of the poor” or “Indian food”. The only way to sell llama meat for a good price, is selling it as alpaca meat, in case the carcass comes from a young animal. This is a common practice. Also mixing of llama meat with beef and selling it as beef minced meat happens frequently (Ruiz personal communication; Wolfinger 2012). Still, recently consumers realize that llama meat is a healthy and sustainable option to other types of meat. Its cholesterol levels are lower than those of for example pig meat and its protein content is higher (Trejo, personal communication).

Also the llama fibre is considered as coarse and uncomfortable to wear and market production of llama fibre is of minor importance. Llama fibre and fleece quality depends very much on the type of llama kept. In the study regions there are mostly K’ara type animals that have no fleece for fibre production. Studies show that llama fibre can have good quality for fine fleece production and some potential on international markets (Markemann et al. 2009). Breeding more Chaku types and rising awareness could help to create another income source. Apart from that, farmers criticised strong influence of intermediaries and the almost monopoly-position of fibre processing companies, that reduce the negotiating possibilities of local farmers (Trejo, personal communication).

Transportation and packing (primarily of agricultural crops) was not observed and was said to be declining, as better roads are being build and accessibility by motorized transport increases (Camino 2002). Caro (1992, as cited in Markemann et al. 2009), Ruiz (2013) and Wolfinger (2012) confirm these statements. Still, 70% of farmers said that they used their llamas from time to time as pack animals.

The use of manure, especially from llama, was mentioned as being an important livestock product. Manure is next to peat the main energy source for cooking, as the research area does not have forest and households still rely on traditional ovens to cook. It is also used to ensure and improve soil fertility (Gade 1999).

Llamas of the Pasco and Daniel Carrion provinces are sold as breeding animals to other parts of Peru, as these animals are known for their good physical characteristics (Wurzinger et al. 2013). Few farmers kept their animals for exhibition in fares or used them as breeding animals. The yearly livestock fare in Ninacaca, Pasco region, with judgement of llama fibre also aims to create consciousness about the value of llamas for livestock production in the region.

\(^{11}\) Sarcocystosis is a parasitic disease caused by the organism sarcocystis. These protozoan parasites use llamas as intermediate hosts and humans as end hosts. In humans, sarcocystis can cause both intestinal and muscular infections (Rooney et al. 2013).
Interestingly, financial functions as wealth accumulation and financial security were never mentioned as livestock functions by the farmers. Other authors as Flores & Bryant (1989) or Markemann et al. (2009) state these as some of the main reasons for llama rearing.

Ruiz (2013) explained that the value of llama hides used to be higher than nowadays, as a special type of shoe was produced (called ojota) using the skin of llamas. But nowadays this product is not commonly produced anymore, as most shoes are imported from abroad. Farmers also said that the sale of llama hides hardly gives any profit, one farmer said that he earns as little as 1 sol (0.3 Euros) per hide.

Llama rearing will only become a viable option to improve the farm’s sustainability, when markets for llama products are successfully established. Already some cooperations were created in the region between producers of llama fibre or NGOs, with an emphasis to support women who sew and sell clothes made out of llama fibre at local markets and fairs.

There is currently a project going on with the aim to establish breeding strategies for llama keepers (Wurzinger 2013). Considering that some interviewed farmers thought that I was a part of this project, the declaration that a quite high number wanted to raise the number of llamas on their farms needs to be handled with caution. It is possible that some farmers were hoping for support of any kind or even donations of llamas to them.

Two of three interviewed experts (Naupari and Ruiz 2013) expressed their worries about the future of llama husbandry in the region. Market prices of meat and fibre are highly volatile and llamas as pack animals are less and less being used. But Palomino (2013) argues that llamas will contribute to the farmer’s livelihoods to a bigger extent in the future, because of the above-mentioned advantages.

7.4.2 Alpacas

Alpacas are relatively new livestock in this zone, traditionally mainly sheep were kept for wool and meat production on large scale. Naupari and Ruiz (2013) explained in their interviews, that governmental programs promoted the husbandry of alpacas in the 1990 because of high prices for fibre and prospects of good income. This turned out to be a rather empty promise, as prices of fibre are volatile and depend on international demand. Another problem concerning fibre production is that a few fibre processing factories and middlemen have power over price assessments.

Apart from fibre production the other main purpose of alpaca husbandry given by farmers was auto-consumption and the sale of their meat. Compared to llama products, alpaca meat, as well as alpaca fibre, has a better image in society and was also observed to be promoted to tourists as a Peruvian speciality. In
touristic places, as Cusco, alpaca meat is offered frequently by restaurants. Dried alpaca meat was also commonly found in local markets, mostly as dried meat called charqui.

Further, alpaca products used by farmers were their hides and manure. Alpaca hides were stated to be more valuable than those of llamas, selling for double the price.

Many of the interviewed farmers stated that they got their highest earnings through alpaca production. This might be reflected in the high herd size numbers of alpacas, and also two farmers were specialized in alpacas. At the same time the farmers mentioned that the costs of alpaca rearing are relatively high because of maintenance and veterinary costs.

Alpaca numbers on the sample farms were increasing in the last 5 years due to good economic benefits. But in the future a little bit less than half of the farmers think about declining the numbers again, as expectations were not always met and alpaca production implicates high maintenance costs.

As a conclusion, alpacas unify the advantages of llamas in the environmental context and sheep in the economic context, just that alpacas were not seen as robust as llamas. Alpacas need more water than llamas, but less than sheep. They are also seen as very feed-efficient. These results show that alpacas will remain being assets in the livelihoods of farmers of the Pasco region.

The observations and results about the better adaptation of SACs to the Andean environment are in accordance with observations of other authors such as Rodríguez & Quispe (2007) or Sumar & Camino (1992). Also Flores & Gutierrez (1995) confirmed that SACs feed more efficiently on especially long forages than sheep.

7.4.3 Sheep
In Peru, the sheep population consists mainly of “Criollo” animals introduced by the Spanish 400 years ago; those animals became naturalized to the harsh environment of the highlands, but sacrificing their productive characteristics because of the lack of genetic improvement programs. Thirty to fifty years ago the introduction of improved breeds like Corriedale led to crossing with the Criollo sheep (Vivanco 1986).

Sheep are being kept in the area for several centuries already (Hunefeldt 2004; Vivanco 1986). Farmers rear them for their meat and their wool, keeping dual purpose breeds. Sheep meat is more popular as meat of SACs, it is sold at every market and restaurant. Objections against sheep meat by consumers were not observed or heard of. Meat prices for sheep are higher than for alpacas, but wool prices are much lower (Ruiz 2013). Farmers reported that wool prices also behaved volatile with a declining trend over the last years.
Other common uses for sheep products were the use of manure, especially as a fertilizer, and the use and sale of hides. Milk production was not observed in the case study area.

Valdivia (2000) found that in Peru sheep husbandry is an important cash-generating activity, enabling the household to purchase products from the market. But this was never mentioned in the interviews. In Bolivia, Valdivia (2004) observed that sheep were used as a buffer when food shortages occurred. At above 3700m sheep (both Criollo and improved) were still used a source of milk as well, so it might be an alternative income source to introduce dairy breeds as well to the lower parts of Daniel Carrion, if accompanying measures as pasture improvement can be met.

Sheep used to be seen as highly productive and good means of income-generation (Palomino 2013), but this view has changed among the interviewed farmers who showed a stronger preference towards alpacas. The environmental disadvantages sheep bring are that they are more demanding with forage and water, need more attention in their management and are more susceptible to diseases. In the literature they are also known to cause soil erosion, which was confirmed by the farmer’s perceptions. Therefore farmers gave a lack of pasture as a reason to reduce the herd size of their sheep, in order to react to the declining pasture quality. But the main reason for declining numbers in the past (that is also expected to continue in the future), was the lower economic benefit made from sheep husbandry. More and more farmers question their economic benefits because of the decreasing market demand for the rather coarse wool of dual purpose sheep.

On top of that, as meat production gives farmers more income than wool production, poor pasture quality could hinder meat production, as forage for fattening is less available. This can furthermore drop the profit made from sheep keeping.

In the long term, it seems that sheep will be kept to a minor extent or will on some farms even be replaced by SACs and cattle in the case study area.

Another livestock function that was observed from llama, alpaca and sheep keepers, but not directly addressed in the questionnaire, was the cultural, religious and social aspect these animals fulfil traditionally in rural communities (van’t Hooft 2002). Some farmers had their animals decorated with colourful ribbons around the ears and legs, usually before they were exhibited at local fairs.

7.4.4 Cattle

Cattle do not have a major focus in this work, as cattle were considered to be kept to a smaller extent than what was actually the case. All farmers kept their cattle for meat and milk production. Interestingly, cattle
manure as fuel for cooking was not seen to be as valuable as the one from the other main livestock species. Cattle were never used for sale as breeding animals.

The herd numbers for cattle were lower than for other main livestock and remained stable in the last years, with a trend to a herd reduction. These results can be explained by several reasons given by the farmers and observed by the author. Keeping cattle was seen as being more costly and management-intensive, as they usually graze on cultivated pasture. Many farmers, especially in the higher zone 1 complained about declining pasture quality and lack of water, so probably higher numbers of cattle cannot be supported in the area.

Still, results show that cattle seemed to be good assets for earning income through milk production. Milk sale gave farmers a rather stable and daily income and act as buffer for alterations (Valdivia 2004). Therefore bit less than half of the farmers thought about increasing their cattle numbers, mostly in zone 2, were pasture and water showed a higher suitability for cattle husbandry.

7.5 To what extent is climate change perceived as a production problem?

As one of the main challenges for society worldwide, climate change is of big concern in agricultural and livestock production systems by impacting natural resources. The consequences of climate change underline the implications of social inequities in resource access, distribution and exploitation around the globe (Castellanos et al. 2013; Mideksa 2010; Deressa et al. 2009). As key concepts in explaining the societal implications of climate change are frequently mentioned vulnerability, adaptation, and adaptive capacity12 (Fussel and Klein 2006). But how these concepts are adopted and applied in the daily lives of farmers being faced with these challenges, needs to be better identified and understood (Below et al. 2012).

Before discussing the results, I want to highlight that climatic variability is known to be a reason for diversification in the sense of production systems and economic terms (Boulier & Jouve 1988, as cited in Hussein & Nelson 1998; Issoufou 2013). The need to work off-farm will probably be increased in the future also by climate change, as a means to decrease vulnerability.

The Andean agro-ecosystems are of fragile nature (Valdivia et al. 2013). In the research area, natural resources showed a rather declining tendency, essentially in zone 1. Pasture quality in zone 2 seems to have been improved due to cultivation and other improvement techniques of natural pasture. This can be the result of extension and capacity-building programmes conducted by local authorities, as Naupari and Ruiz (2013) explained in the expert interviews. The implementation of pasture improvement techniques

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12 Adaptive capacity refers to the flexibility to face long-term modifications in the environment, which may imply modifications to processes and operations of the system (Masera et al. 2000, as cited in Bernués et al. 2011).
especially in the poorer zone of the case study area contradicts findings of Ellis-Jones and Mason (1999) during their research in Bolivia. They argue that conservation technologies are rarely applied by poor farmers as a consequence of a lack of resources.

Physical water availability and reliability in the farmer’s perception were not sufficient. This fact corresponds with the findings of Wolfinger (2012). A lack of water is also related again to pasture quality, as water for irrigation techniques gets limited (Swiech et al. 2011). Besides using water for irrigation (what was not a common practice and rarely observed) or as drinking water for animals, it is also needed for anti-parasitic baths against diseases. So water availability and reliability are crucial for successful animal husbandry. A lack of water increases the vulnerability and decreases the chance of sustainable livelihoods of farmers (Lynch 2012).

Interestingly, in zone 1 farmers faced more decline in pasture quality and water availability. This can be explained by higher altitudes of the villages in the zone. This decline can also be used to explain the lower number of cattle (less than 30% of cattle can be found in zone 1) and the planned further reduction in cattle numbers in the future. Farmers realized that the dietary requirements of dairy cattle cannot be met under these conditions.

Climate change represents a phenomenon to which farming contributes to in parts and to which it is especially vulnerable, since most farming depends on the weather (Hazell et al. 2010). Bearing in mind that farmers usually base their decisions on local knowledge systems that have been developed through years of observation and experience (Gilles & Valdivia 2009), it is interesting that all interviewed farmers knew the term “climate change” and answered immediately that they noticed effects of climate change in their production systems. Changes in temperature, annual and seasonal rainfall patterns and an increased frequency of extreme events were often mentioned. The most common effect observed was a colder environment, temperatures were lower than they used to be and more frequently below 0°C, leading to more snow and frost. In an already quite cold environment this climatic change is not helpful for animal production. Many farmers said that the temperatures were rising and falling at the same time, meaning that the seasons shifted noticeably. A common observation was that during the rainy season there was less rain and during the dry season there was more rain than expected, making seasonal livestock activities difficult to schedule. This explains the lack of water reliability farmers complained about.

To decrease vulnerability, almost 60% of farmers applied strategies to cope and mitigate the negative effects on their livestock and eventually on their income. Most farmers relate a higher mortality and morbidity to effects of the changing climate. Interestingly one farmer said that the climate change is not the main reason
for these events, but rather species that are not adapted to the environment (making reference to crossbreeds of sheep and cattle species).

These results suggest that consciousness and the perception of climate change as a major production restraint are definitely given. Farmers openly demanded governmental support to prepare for and mitigate the negative consequences of climate change on the health of their livestock. This was also reflected in the wish to improve the genetics and health of the animals to enhance animal productivity, which was a common goal mentioned by farmers. Programmes to improve livestock genetics, especially of sheep, cattle and alpaca, are not very common, but animals used for reproduction get exported to other departments as Puno and Junín. But there is only one program with a focus on llama genetics in the case study area. It is being conducted by livestock researchers and technicians from UNALM. Different breeding strategies were developed and implemented in various study sites (Wurzinger et al. 2013).

Another environmental topic that was addressed by some farmers and should be mentioned here was the fear of atmospheric pollution from mining industry. At least one farmer planned to take action against it by planting trees. Also a general concern for pollution and following environmental and health degradation because of mines could be noticed in the population (Wolfinger 2012).

Limited capacity of resource-poor farmers in the region to adapt to the changing environment suggests the need for governmental and institutional support to ensure rural resilience and long-term sustainability of these livestock-farming systems. As in many other Latin American countries government policies in the past favoured urban consumers at the expense of rural producers (Vera 2006). Also adaptation to climate change has been subordinated to the economic interests of the state (Lynch 2012, Palomino 2013), so room for improvement is given. Within this context, the adaptive capacity of livestock farming systems in the Andes to adjust to new restrictions becomes crucial. Maybe also new opportunities generated by the changing environment appear.

8. Conclusions

The livelihood strategies chosen by the farmers are very diverse and hard to classify, showing a deep uncertainty in the right strategy to adapt to keep making a living as livestock producers in their villages.

Regarding the chosen production strategy, the system can be described as a low input-low output system. Most farmers can be seen as diversified, as most of them keep a broad range of livestock species. Main species identified were alpacas, sheep, llamas and cattle. But also many other livestock species can be found in different numbers. This can be seen as a way to increase the resilience towards economic and climatic
shocks. Only a small number of farmers can be seen as specialized. Those are specialized to livestock that gives a relatively high income under the market conditions that applied at the time of the case study. Considering the composition of the livestock species, farmers experienced an increase in alpaca numbers and a decrease in sheep numbers over the last five to ten years. This mostly reflects market conditions, as the prices for alpaca fibres rose and the prices for wool declined in the same time period. But now with the effects of climate change strongly noticed, farmers prefer to keep a higher number of llamas in the future, as llamas are seen to be resistant and adapted to the changing environmental conditions. But the market for llama products is small and income is limited, so farmers still rely on alpacas, sheep and especially cattle to earn the income they need to make a living.

More than half of the farmers diversify their livelihoods via non-livestock income. This diversification also seems to be crucial to maintain rural livelihoods in the case study area by providing flexibility among sources of income, in case income from livestock production fails. The importance of non-agricultural employment for successful income generation is critical at the time of the case study and is expected to rise in the future. As it is usually the male farmer who finds employment outside the farm or even has to migrate temporarily or permanently, leaving the women and family behind on the farm, social changes are expected to happen in this rural society.

The reasons for this strong economic and livestock-related diversification can be found in the variabilities of climatic and market conditions. These can be seen as the main drivers of change in these rural economies and societies. This vulnerability is expected to increase in an environment where water availability and reliability are more likely to fluctuate due to climate change.

Need for action to improve the farmer’s situation is given. Investment for improvements in infrastructure and extension especially for smallholders is acknowledged to be an absolute necessity to support smallholder farmers. To ensure the sustainability and the rural resilience of the present livelihoods of the farmers in the case study area, support is needed in many ways by policy programs.

Finally, the question of the improvement of livestock farming cannot be detached from the question of the evolution of the markets. Well-elaborated marketing strategies focussed on the health benefits of llama and alpaca meat and other animal products could help to raise the consciousness of the customers. The Peruvian society could support their smallholder farmers by generally esteem the lifestyle and ancient traditions of the farmers of the sierra more.
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Annex

Questionnaire

INFORMACIÓN GENERAL

1. Nombre:

2. Sexo: F M

3. Edad:

4. Centro poblado:

5. Distrito:

6. Celular:

7. Estado civil:

   Conviviente
   Casado
   Divorciado
   Viudo
   Soltero

8. Nivel educativo:

   Asiste a programas de alfabetización
   Lee y escribe
   No tuvo educación escolar
   Primaria
   Secundaria
   Estudios superiores
   Título profesional

9. Personas que viven en la casa; número, edad y sexo:


10. Cuántos miembros aportan económicamente al hogar?

Miembro 1  Miembro 2  Miembro 3  Miembro 4

Edad
M o H
Trabajo interno o externo

11. Cuáles de ellos trabajan en ganadería, en qué trabajan los demás?

Miembro 1  Miembro 2  Miembro 3  Miembro 4

(NON-) FARM-INCOME

12. Actividades económicas (fuente de ingresos) de la familia: (1=aporta casi el 100% de sus ingresos, 2=75-50%; 3=50-1%)

Ganadería  Agricultura (cultivos__________)  Artesanía (productos_______)  Minería (lugar_______)
Turismo (lugar_______)  Comercio (lugar_______)  Construcccion (lugar_______)  Otros

13. Cuál es la importancia actual de la ganadería para la economía familiar comparando con hace 5 años atrás? Mas importante Igual Menos importante

14. Si ahora trabaja más fuera de la ganadería: Por qué usted ahora trabaja más fuera de la ganadería que antes?

Porque no rinde económicamente
Por mejores oportunidades laborales
Motivos familiares
No tiene tiempo suficiente
Edad
Estudios
Regaló o vendió animales
Otros

15. Si también trabaja fuera de la ganadería: Cuánto tiempo en la semana usted trabaja en los sectores mencionados?
Todos los días  5 a 6  4 a 3  1 a 2 días por semana

16. Como fue la situación hace 5 años? Mas o menos fuera de la ganadería por?

17. Todavía queda suficiente tiempo para la ganadería? Sí No

18. Si también trabaja fuera de la ganadería: El tiempo que dedica a sus actividades ganaderas varía de acuerdo a la estación del año?  □ Sí □ No

19. Cuales son las variaciones?

20. Si contesta con Sí: En qué meses al año usted trabaja en estas actividades?
□ ENE □ FEB □ MAR □ ABR □ MAY □ JUN □ JUL □ AGO □ SET □ OCT □ NOV □ DIC

21. Piensa hacer algún cambio en la fuente de ingresos en el futuro? Sí No

22. ¿Qué tipo de cambio? □ Invertir más en ganadería, como compra de más animales
□ O invertir más en non-farm actividades

23. Por qué?

24. Usted ha pensado una vez de dejar de criar animales y trabajar en otra cosa? Sí No

25. Por qué? Cambios en mercado Cambio climático Alta mortalidad Baja productividad Programas del estado Otro

RECURSOS NATURALES

26. La calidad del pasto ha mejorado, se ha mantenido igual o ha empeorado en los últimos 5 años?
Mejorado Igual Empeorado Por qué? Falta de agua Clima

27. Cuenta con fuentes de agua suficientes todo el año? Sí No

28. Como ha sido el abastecimiento de agua ha aumentado, es igual o ha disminuido con respecto a haceen los últimos 5 años? □ Aumentado □ Igual □ Disminuido

CAMBIO CLIMÁTICO

29. Ha notado un cambio en el clima en los últimos 5 años? Sí No

30. Si contesta con Sí: Cuáles son los efectos que usted nota?
Mas/menos precipitación y agua en los ríos Temperaturas más altas o bajas Menos pasto de buena calidad disponible Mas/menos nevados Otro
31. Qué efecto tienen estos cambios para usted y su ganado?

Más mortalidad    Enfermedad    Menos produccion    Otro

32. Usted aplica estrategias contra estos efectos? Si No

Si contesta con Sí: Cuales?    Construir techos para los animales    Bebedores    Arboles contra viento

Otro

33. Usted cree que el cambio climático sería una causa que lo obligaría a pensar en una alternativa a la ganadería o pensar en dedicarse a otra actividad o a criar varias especies? Si No

GANADERIA

34. Que especies cría usted?

Especie Número

Vaca
Ovino
Llama
Alpaca
Equino
Cerdo
Cuy
Conejo
Pollos/Patos

35. Tendencia de población de animales en los últimos 5 años:

Llama:  Aumentado|Disminuido|Se ha mantenido| Causa:

Causa: Razones economicas    Pastos Agua    Enfermedades Economia    Otro

Alpaca: Aumentado|Disminuido|Se ha mantenido| Causa:

Causa: Razones economicas    Pastos Agua    Enfermedades Economia    Otro

Ovinos: Aumentado|Disminuido|Se ha mantenido| Causa:

Causa: Razones economicas    Pastos Agua    Enfermedades Economia    Otro
Otros_____________: Aumentado|Disminuido|Se ha mantenido| Causa:
Causa: Razones economicas   Pastos   Agua   Enfermedades   Economia   Otro
Otros_____________: Aumentado|Disminuido|Se ha mantenido| Causa:

36. Piensa aumentar el número de su ganado?

Llama: S  N  Causa:
Alpaca: S  N  Causa:
Ovinos: S  N  Causa:
Otros: S  N  Causa:

37. Por qué motivo cria llamas?  Por qué motivo cria alpacas?  Ovinos?  Otros

(marcar 2 o 3 para cada especie)

Carne  □  □  □  □
Fibra   □  □  □  □
Estiércol □  □  □  □
Carga  □  □  □  □
Piel  □  □  □  □
Tradicion □  □  □  □
Otros  □  □  □  □

38. Con cuál animal usted tiene más ganancia? (Ranking 1= más, 3 o 4= menos)

Llama  Alpaca  Oveja  Otro

39. Ventajas de llamas  Ventajas de alpacas  Ovejas

(marcar 3 o 4 para cada especie, usar “+” para bien (mucho), “~”normal/neutral, “-”mal (poco))

Tolera frío  □  □  □  □
Tolera altura □  □  □  □
Tolera sequia □  □  □  □
Aprovecha mejor del pasto □  □  □  □
Menos enfermedades □  □  □  □
Reproducción alta □  □  □  □
Mercado para productos □ □ □ □
Facilidad de manejo en general □ □ □ □

40. ¿Qué especie usted cree consume más agua? Llama Alpaca Oveja
41. Cuál especie aguanta más tiempo sin agua? Llama Alpaca Oveja
42. Que especie usted cree consume más alimento? Llama Alpaca Oveja
43. Cuál menos? Llama Alpaca Oveja
44. Hay una especie que empeora más el suelo y el pasto? Sí No
45. Cuál es? Llama Alpaca Oveja
46. Cual animal genera más costos en mantenimiento, poner la infraestructura y el equipo, comprar medicamentos para el veterinario? Llama Alpaca Oveja

ESTRATEGIA DE PRODUCCION – DIVERSIFICACION VS. ESPECIALIZACION

47. Si criador cria especies diferentes: Usted dedica el mismo tiempo y los mismos recursos a criar su ganado (llama, alpaca, oveja y otros)? (Dibujar un círculo de tiempo y uno de recursos) Sí No
48. Si criador contesta con Sí: Por qué usted cria los especies con la misma prioridad?
....
49. Si criador contesta con No (mas que 75% de los ingresos): Por qué usted dedica más tiempo a criar una especie?
....
50. Cual es? Llama Alpaca Oveja Otro

51. Si criador cria varias especies: Quiere enfocarse mas en una especie en el futuro/reemplazar una especie por otra? Sí No
52. Por qué?
53. Cuál cree, en general, es lo mejor, criar solo una especie o varios especies de ganado?
Solo una Más que una

54. Cuáles, en general, serian los principales ventajas y riesgos de criar varias especies?
Ventajas Diversificacion en caso de enfermedad Cambio de mercado Otro
Riesgos Perdida de ingresos por bajos precios Otro
PREGUNTAS ABIERTAS PARA FINALIZAR

55. Que le gustaría a usted mejorar o cambiar de su estrategia de producción de ganado?

______________________________________________________________

56. Que deseos tiene usted para el futuro?

______________________________________________________________