Australian Government

Australian Centre for International Agricultural Research

Final report

Enhancing small ruminant production to benefit farming families in Sindh and Punjab, Pakistan

project ID	LS/2018/105
date published	12/12/2022
prepared by	Angus Campbell, Anna Barrett, Muhammad Atta ul Zia, Abdul Hussain Memon, Sunbal Sarfraz, Samia Rajput, Saba Ashraf, Dennis La, Haroon Muzzaffar and Rebecca Doyle
approved by	Dr Annal Okello
final report number	FR2022-033
ISBN	Enhancing small ruminant production to benefit farming families in Sindh and Punjab, Pakistan
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

Contents

1 Acknowledgments 4

2 Executive summary 5

3 Background 6

3.1 Country context 6

3.2 Small ruminant farming in Pakistan 6

3.3 Smallholder goat value chains: challenges and opportunities 6

3.4 Family and gender roles in SR farming 7

3.5 SR production constraints and opportunities 7

3.6 Summary 8

4 Objectives 9

5 Methodology 10

5.1 Project design 10

5.2 Data collection and management 11

5.3 Ethics and consent 11

5.4 Summary table of methodologies of research activities 12

5.5 Objective 1: Develop and test improved production practices to increase the growth and off take of small ruminants 16

5.6 Objective 2: Develop and test strategies small ruminant farming families can use to access market opportunities and attain market specifications 19

5.7 Objective 3: Identify and trial opportunities for women and their families to derive more benefits from small ruminant production and marketing 20

6 Achievements against activities and outputs/milestones 21

6.1 Impacts of COVID-19 on project achievements 21

6.2 Overview of project achievements 21

7 Key results and discussion 33

7.1 Existing SR management and household member roles 33

7.2 Areas of loss and opportunities for improvement 38

7.3 Zoonotic disease 48

7.4 Strategies to improve survival and growth of young animals 49

7.5 Potential for improving smallholder livelihoods through engagement with value chains 55

7.6 Opportunities for women and their families to derive more benefits from small ruminant production and marketing 58

7.7 Summary of key results 59

8 Impacts 61

8.1 Scientific impacts – now and in 5 years 61
8.2 Capacity impacts – now and in 5 years 62
8.3 Community impacts – now and in 5 years 65
8.4 Communication and dissemination activities 68

9 Conclusions and recommendations 71
9.1 Conclusions 71
9.2 Recommendations 72

10 References 74
10.1 References cited in report 74
10.2 List of publications produced by project 75

1 Acknowledgments

We are very grateful to the hundreds of farmers who generously participated in all of the field research undertaken by the project. We also acknowledge the generous support of staff from the Punjab Livestock and Dairy Development Department and the Sindh Livestock Department who facilitated community engagement and field operations.

Thank you to Meritorious Professor Dr Talat Naseer Pasha (SI) and Professor Dr Nasim Ahma (SI), immediate past and current (respectively) Vice Chancellors of University of Veterinary and Animal Sciences Lahore for their unstinting support of our project.

Thank you to the numerous Non-Government Organisations who collaborated with us on training, and staff and farmer capacity development activities, as well as staff and students from the University of Veterinary Sciences, Lahore and Sindh Agriculture University for such wide-ranging research collaboration.

Thank you also to staff from the Australian High Commission, particularly AHC drivers who oversaw all of the transport for Australian staff during their time in Pakistan. We are also very grateful to staff from the United Nations Food and Agriculture Organisation in Pakistan for opportunities to collaborate outside of Punjab and Sindh early in the project when activities were scaled out to Balochistan.

Thank you to other research collaborators and colleagues from the wider Aik Saath Program for the collegial spirit of research cooperation across our different projects.

2 Executive summary

Smallholder families dominate goat and sheep (small ruminant) production in Pakistan, and small ruminants are very important nationally to consumers and farmers. As well as being highly valued for routine domestic consumption, goats and sheep are sacrificed in at Eid al-Adha, a deeply significant annual observance for Muslims globally. Small ruminants are raised in smallholder herds/flocks with typically six or seven breeding females and all members of the family may contribute to livestock management. Women particularly care for young animals at home and do the vast majority of work for this class of livestock stock. Selling animals for meat contributes most to income earned from small ruminants but the majority of households also consume goat and sheep milk. This is an important potential source of zoonotic disease, as many households consume raw milk, perform practices that expose humans to infections from small ruminants, or have a poor understanding of zoonotic disease risk.

Farmers, especially poor communities and women, are disconnected from inputs and services that are necessary for efficient livestock production and trade, including technical information and training, and markets. In general, although there are gaps in smallholder farmers' knowledge of key strategies to successfully manage SR production and health, they are information-seekers and know topics they want training for.

Existing mortality averages 9% per annum for breeding females and 19% for young goats, representing enormous lost potential and inefficiency in livestock production. Farms are often affected by disease outbreaks or suffer chronic, sub-clinical health problems. Anaemia is a very widespread problem, with 50+% of adults affected at some times of the year. Ticks or tick-borne haemoparasites could be important causes of the condition but more investigation is needed to identify its cause(s) and treatment.

Several simple interventions can effectively help overcome some of these constraints. Providing leguminous feeds in smallholder goat and sheep farms reduced mortality by 42% compared to offering other kinds of feeds. Creep feeding, which involves offering high-quality feeds behind a barrier that only allows access by young animals, cost-effectively increased growth, survival and sale price of young goats and sheep. Typical increases of 5–10% of existing liveweight value were achieved, although individual farmers received 2–3 times typical prices. It was readily accepted by farmers if locally available feeds were used and farmers were trained in its use through participatory, action learning approaches.

Smallholder farmers were generally disadvantaged in trading transactions, and typically were not aware of the key animal traits and specifications sought by buyers at Eid al-Adha and other times of the year. Farmers' visual assessments of liveweight are often inaccurate. However, using weigh scales at selling time significantly supports trading, with 80% of trial farmers reporting it improves their livestock sales.

Such interventions are readily adopted by smallholder farmers, including women. It is critical that capacity development resources such as workshops and training materials are accessible to women, which can be achieved by using literacy-appropriate formats, socially accessible settings for meetings and service delivery by other women. These approaches, combined with low-cost, practical interventions, can lead to strong, sustainable uptake by farmers that improves Pakistan's small ruminant production, increases household incomes and strengthens farmer livelihoods.

3 Background

3.1 Country context

Pakistan is the 5th most populous country in the world, with an estimated 207.7 million inhabitants (Pakistan Bureau of Statistics 2017). Currently, two thirds of the Pakistani population live in rural areas, 68% of rural households are employed in agriculture, and agriculture-related enterprises employ 45% of Pakistan's overall labour force. Furthermore, an estimated 45% of the Pakistani population is experiencing multidimensional poverty and living on less than $2 per day (United Nations Development Programme 2016) and illiteracy rates are around 40% (UNICEF 2011). Future projections have Pakistan's population set to double by 2050 (United Nations 2017). In combination, this creates a major need to enhance the livelihoods of the rural poor and a clear opportunity to do so through the sustainable production of food into the future.

3.2 Small ruminant farming in Pakistan

Smallholder families dominate small ruminant (SR) production, and SRs play a very important role in Pakistan for consumers and farmers (Collins and Dunne 2015). Goat and sheep meat, generically referred to as 'mutton', is prized in Pakistan. As well as being highly valued for routine domestic consumption, goats and sheep are sacrificed in huge numbers (9 million goats, sheep, cattle and camels over 2-3 days in Pakistan) at Eid al-Adha, a deeply significant annual Muslim observance.

Livestock numbers have increased in Pakistan in recent decades, but this has not been matched by increases in fodder availability or overall productivity (Burton *et al.* 2012). Key priority areas for Pakistan at both national and provincial levels include improved livestock research and extension capacity (Burton *et al.* 2012; Livestock and Dairy Development Department 2017). The Pakistan Planning Commission identifies that low productivity per animal, very poor animal health coverage, inadequate feed resources, livestock skills shortages, poor marketing and weak research and extension systems are key problems in the livestock sector. Similarly, provincial governments, which now oversee livestock development and policy, recognise that livestock play a critical role in rural livelihoods but that research to support production and marketing is insufficient (Livestock and Dairy Development Department 2017). Historically, improvements in livestock feeding, health and marketing have all been identified as key issues, although pathways to improve this have not been clearly identified. Other sector assessments and the preliminary research performed prior to this project (see below) identify strikingly similar themes of poor productivity, unmet market potential, inadequate extension and animal health services despite farmer demand as key sector constraints. These are widespread across regions and availability of resources in other livestock sectors.

3.3 Smallholder goat value chains: challenges and opportunities

In 2017, this research group conducted the ACIAR-funded small research activity (SRA): LPS/2016/096 - *Smallholder goat value chains in Pakistan; challenges and research opportunities*. The findings described SR production systems, and constraints and opportunities throughout the value chain in Punjab and Sindh. A rapid value chain analysis identified four interlinked mutton value chains:

1. A 'Traditional Domestic' value chain supplying traditional wet markets;

2. A 'New Domestic' value chain involving higher-end consumers buying chilled meat in supermarkets and speciality butcher shops;

3. An 'Export' value chain, shipping chilled carcases by air to shops and consumers, especially expatriate Pakistanis, in the Middle East;

4. A 'Religious' value chain in which animals are purchased for sacrifice during festivals such as Eid al-Adha (Eid) and for other religious observances

The first three value chains directly compete for a very similar product, namely animals 12-18 months old, with carcass weight of 8-12 kg (and up to ~18 kg). However, it is unclear what proportion of traded animals meet the preferred market specifications, how well different value chain actors understand these specifications, or the opportunities offered by meeting specifications more consistently. The fourth value chain (Religious) operates throughout the year but intensifies before the Festival of Eid. It is culturally very prominent and accounts for about one third of the total annual slaughter volume of SRs (9 million out of an estimated 25 million animals slaughtered annually). Generally, trading networks appear to operate efficiently over wide geographic areas, with traders and agents sourcing animals from areas dispersed over hundreds of kilometres, according to price and availability.

By-products like wool, milk and leather are not a common source of income in Punjab or Sindh. Milk is consumed in the household, and there may be opportunities to derive income when excess is produced.

In the SRA, substantial upward pressure on prices was frequently reported. This was perceived to threaten the sustainability of value chains, especially export, as well as individual trader and butcher operations. Multiple causes were suggested, including low and inconsistent supply of animals for sale by farmers, and provincial government policies that restrict supply or distort prices. Upward pressure indicates that available markets could accommodate substantially increased mutton production.

3.4 Family and gender roles in SR farming

The SRA found that women's roles in raising SRs chiefly involve feeding and caring for stock, especially young animals. They seldom deliver health care or interact with animal health providers. Men identified themselves as chiefly being involved in decision-making and grazing in SR enterprises.

Women reported that they and their children did substantially more day-to-day work with SRs, particularly with the young animals, than men's reports. Women appear to work less with livestock generally in households where SRs provide secondary income.

3.5 SR production constraints and opportunities

The SRA confirmed that poor supply (quantity, quality and consistency) of animals from farms was a major restriction in the operation of Pakistan's various SR value chains and the opportunities for women and men to derive value from SR farming. Key factors behind this included illthrift and mortality of young animals, and poor husbandry, health and nutritional management of different livestock classes.

Farmers reported that extension material and support for SR production was practically non-existent. Similarly, insufficient extension services were identified by government veterinarians and veterinary assistants as an important constraint to production, despite the government's key role in extension. Where services existed, they were based on limited evidence and may be poorly coordinated.

Thus, the most important constraints to the benefits smallholders and others may obtain from SRs exist on-farm rather than further along the value chain. Target issues include illthrift and mortality of young animals, appropriate nutrition and improved health of stock, backed by practical, evidence-based extension and engagement programs for farmers and other value chain actors. The structure of the value chains means that smallholder

farmers have opportunities to capitalise on the high market demand for SRs, but limitations to the number and quality of animals they produce prevent this. Thus, practical research must overcome these limitations.

Supply and quality could be increased by engaging with the whole family because women and youth, not just men, play a critical role in goat/sheep farming. Engagement of women is critical, as it and provides the opportunity to improve the livelihoods of SR farming families and to empower and benefit women within these families. Crucially, this must be done in a culturally respectful way for all members of the family. This will support sustainable growth of all SR value chains in Pakistan and address wider sectoral constraints.

3.6 Summary

In summary, the SRA's key findings, consistent with other reviews of the sector, were:

- Mutton (meat from SRs) is highly valued and there is a clear demand for it across a variety of interlinked value chains;
- There are good trading networks linking small holder farmers with the rest of the value chain, although different value chain actors do not always seem aware of the options they have for connecting with different value chains;
- Poor supply (quantity, quality and consistency) of animals from farms is the major restriction in many value chains;
- Profitability and expansion of emerging markets (e.g. export) is potentially constrained by this limited and/or inconsistent supply of animals;
- Extension and other services for SR farmers are very limited. Where they occur, they are infrequently evidence-based, and government programs may be poorly coordinated or inconsistent, which limits their impact;
- Smallholders could capitalise on high market demand, but there are barriers that prevent smallholder farmers from increasing supply and improving production;
- Women and children play a critical role in goat/sheep farming. Supply can be increased by engaging with the whole family. However, the impact of increasing animal numbers and management methods on these groups needs to be considered.

While these limitations can be broadly identified and classified, solutions to such issues inevitably involve complex interactions of mixed farming systems priorities, family workloads, and land and resource availability and accessibility. The current project was therefore designed to balance studying a broad sweep of issues with delivering practical, impactful research. The project took a development-focused approach, and sought to test strategies for achieving modest impact quickly and at a localised scale, while also identifying further research needed to accelerate more widespread growth in the goat and sheep sector in Pakistan.

4 Objectives

Overall Aim: This project aimed to improve the livelihoods and wellbeing of men, women and youth in SR farming families through more market-oriented animal production and more effective engagement with the SR value chains.

Objective 1 Develop and test improved production practices to increase the growth and off-take of SRs [approximate effort: 40%]

Relevant Research Questions

1: How can SR farming families improve the survival and growth of young animals in an inclusive way?

2: How can SR farming families increase flock productivity through improved management, breeding and health?

Objective 2[1] Develop and test strategies SR farming families can use to access market opportunities and attain market specifications [35%]

Relevant Research Questions

3: What are the opportunities for men and women to engage more effectively in SR production and marketing, and what support is needed to facilitate equitable engagement?

4: What are the incentives for male and female farmers to target specific value chains, and what strategies are needed to achieve market specification of different value chains?

Objective 3 Identify and trial opportunities for women and their families to derive more benefits from SR production and marketing [25%]

Relevant Research Questions

5: What are the economic and social benefits to men, women and youth from a more efficient, profitable and equitable SR farming business?

[1] Note that the titles of Objectives 2 and 3 were incorrectly aligned with their actual activities in the original Project proposal. The activities listed in Objective 2 are related to SR value chains, and the activities under Objective 3 investigate family roles, benefits and engagement in SR farming. Compared to the original project proposal, the titles of Objectives 2 and 3 in this Final Report have been swapped so that they match the described activities more accurately.

5 Methodology

5.1 Project design

The topic and methodological focus of the project's research activities were informed by the outputs of the Small Research Activity *LPS/2016/096 - Smallholder goat value chains in Pakistan; challenges and research opportunities*. Topics for on-farm research were further refined in the project Inception Workshop in February 2019, with participants from Sindh and Punjab Livestock Departments, universities, key national and provincial non-government organisation (NGOs), international/intergovernmental institutions including FAO and ILRI, commercial companies and farmers.

Within each objective, early research activities focused on describing elements, constraints and opportunities of smallholder SR farming systems. The key issues identified through these activities informed the interventions subsequently designed, tested and scaled out. This process was not siloed within Objectives; issues described through one Objective's research findings were addressed in activities of other Objectives if appropriate, and activities contributing to multiple Objectives were incorporated into several studies.

An overview of key research components is given in Figure 1 and elaborated in Table 1. Table 1 lists the significant research components within the project and cross-references each to the related Objectives & Activities as described in the project proposal. Further details of key studies are provided under the sections for each Objective, below.

Sites for field studies were selected based on prior experience of project team members and advice of local stakeholders including Livestock Departments and NGOs. Villages were qualitatively assessed as representing typical examples of smallholder SR

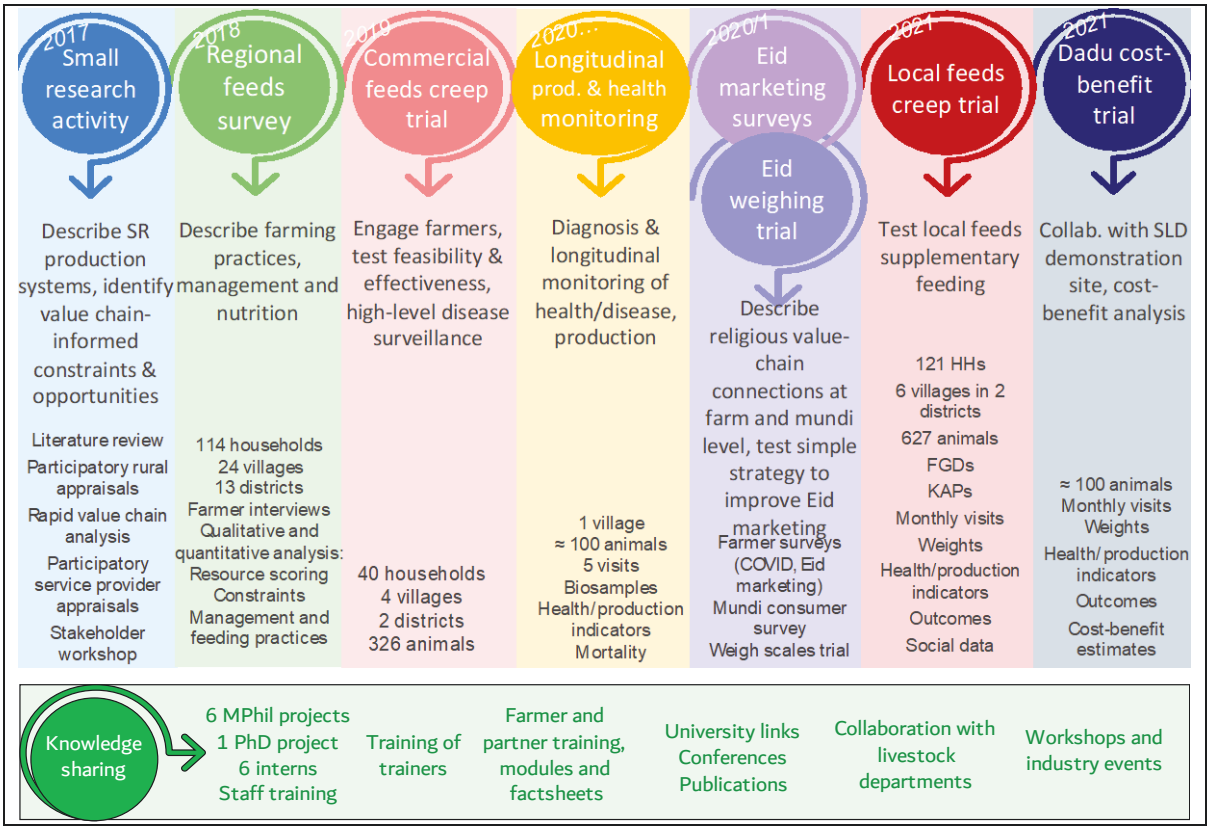

Figure 1: Timeline of major research & other project activities

production systems, based on herd size, household demographics, agroecology and location relative to key physical and economic resources such as livestock markets and population centres. The villages were in a range of rainfall environments and had different histories of development activities, such as previous NGO projects or livestock department initiatives.

5.2 Data collection and management

Most data were recorded on tablets or mobile phones using custom forms developed by the project team in the digital data collection software *CommCare* (Dimagi Inc. 2022).

Fifteen forms and surveys were developed by the project. These are available for other researchers and would be useful and relevant to collecting field data and research with smallholder farmers in many settings.

5.3 Ethics and consent

Human and animal research ethics approval was obtained for all studies from the University of Melbourne Human and Animal Research Ethics Committees. Field trials were conducted in a participatory manner. Typically, the project team ran an introductory meeting or workshop with women and men farmers to explain the purposes of a study and eligibility for participation, and to request farmer consent. For interviews and surveys, female and male team members visited individual households to consult women and men respectively, to describe the study and request verbal consent according to research ethics approvals.

5.4 Summary table of methodologies of research activities

Table 1: Overview of studies performed in LS-2018-105

Study	Related Objective & Activity[2]	Aim, Study Structure & Key Measurements	*Sample*	Conducted by
Regional Feed Survey	1.1	• Cross-sectional descriptive field survey of SR smallholder enterprises across Punjab & Sindh • Descriptive overview of typical smallholder SR farming systems, measuring: ○ Incidence rates (number per average number of breeding females on farm for the preceding 12 months) of births, deaths and animals reaching saleable age ○ Semi-quantitative assessment of availability of land, fodder, energy/protein, degree of feed & water scarcity ○ Kinds of fodder & feeds offered throughout year	114 households from 24 villages across 13 Districts in Punjab and Sindh 127 farmers interviewed: Punjab: 51M Sindh: 13F and 114M	Project team with support from LD[3] staff
Religious Value Chain Consumer Preference survey	2.1	• Cross-sectional questionnaire survey to describe consumer preferences & challenges buying animals at Eid al-Adha	53 consumers	Project team
Domestic milk use survey	3.1	• Describe consumption & role of goat and sheep milk by village households	173 men and 54 women	Project team
Pilot creep feed trial	1.3, 3.1	• Randomised controlled trial comparing 'creep[4]' feeding of a commercial feed to routine management in 4 villages (2 control, 2 intervention) in Punjab & Sindh • Measurement: Growth, health & survival of individual SRs (6 weeks–6 months old) over 6 months • Questionnaire survey at end of trial to assess knowledge, attitude & practice (KAP) change of participating farmers neighbouring households	36 households / 326 animals	Project team

[2] *Objective.Activity—see Table 2 to Table 4 (Section 6) for more details. Note that one Activity may have been comprised of several studies.*

[3] *LD: 'Livestock Department'—the Provincial livestock departments, Sindh Livestock Department and Punjab Livestock and Dairy Development Department*

[4] *'Creep' feeding involves offering supplementary feed behind a barrier that only permits access by young animals. These studies typically used a bamboo fence barrier with gaps big enough to permit access by animals younger than about 6 months of age*

Study	**Related Objective & Activity**[2]	**Aim, Study Structure & Key Measurements**	***Sample***	**Conducted by**

Longitudinal health monitoring	1.2	• Longitudinal observational field study in 6 villages (3 Punjab, 3 Sindh) to identify key health & production issues for smallholders
		• Serum collected for FMD, PPR, CCPP serology
		• Intended measurements:
		  ○ Weight
		  ○ Condition score
		  ○ PCV & FAMACHA (anaemia)
		  ○ Worm egg count
		  ○ Other health: dag, cuts, descriptive health observations
		  ○ Births, deaths, sales, purchases
		• Planned to conduct participatory testing of health interventions on case-by-case basis
		• Study scaled back due to rolling COVID-19 lockdowns throughout 2020 with only limited ongoing sampling in 1 village (Bhurpur, Punjab)
			10 households/village registered (1170 animals)	Project team, 4 MPhil students

Creep feeding at Sindh Livestock Department Research Farm, Dadu	1.4	• On-station demonstration of using creep feeding in young Kamori goats (<6 months old) over 6 months to estimate benefit:cost of creep feeding • Measured growth rate, survival, health status & feeding costs	46 kids & their dams	Project team with support from LD staff
Impact of COVID-19 on livestock production and marketing	2.2	• Cross-sectional questionnaire survey of customers buying SRs in 3 livestock markets in Punjab • Telephone interviews on COVID -19 impacts	38 farmers	Project team
Local creep feeds trial	1.1, 1.3, 3.1	• Randomised controlled trial comparing 'creep' feeding using local village feedstuffs to routine management in 6 villages in Punjab & Sindh • Growth, health & survival of individual SRs (6 weeks–6 months old) compared over ~8 months • Assessed KAP change (pre- & post-trial) of participating farmers	121 households / 627 animals	Project team & 1 MPhil student, supported by LD staff
Prevalence & impact of gastrointestinal parasitism in creep feeding	1.2	• Randomised controlled trial of impact of creep feeding on gastrointestinal parasite infections in young SRs conducted in parallel with local creep feeds trial • Measured growth & health status (anaemia, diarrhoea)	121 households / 627 animals	1 MPhil student, supported by project team

Study	**Related Objective & Activity**[2]	**Aim, Study Structure & Key Measurements**	***Sample***	**Conducted by**
Effect of selenium supplementation on growth of young SRs	1.2	• On-station randomised controlled trial of different forms of selenium supplementation	60 crossbred goats	1 MPhil student
Smallholder SR marketing practices at Eid (2020, 2021)	2.2	• Questionnaire survey of SR trading practices & perceptions by smallholders • Collected data on buying intentions, and expected prices & animal specifications	184 (109M + 75F) farmers	Project team
Effects of using scales to facilitate SR trading at Eid	2.2	• Intervention study assessing farmer practice, knowledge & perceptions of using weigh scales to facilitate SR trading at Eid	34 farmers	Project team with help of Village assistants
Knowledge, attitudes & practices of women & men farmers towards zoonotic disease	3.1	• Mixed-methods observational questionnaire study of knowledge, attitudes and practices towards managing & preventing zoonotic diseases in households	38 farmers (focus group discussions) / 121 farmers (structured survey)	1 MPhil student, supported by project team
Preslaughter influences on carcass and meat quality	2.1	• Observational study of animal health & production during abattoir lairage • Measurements: weight, health status, final price paid, carcase measurements	300 goats	1 MPhil student
Development and delivery of extension material on animal health and management, including Training-of-Trainers	3.2	• Primarily a capacity development activity for farmers or animal health & community development workers • Measurements included post-training evaluation surveys	1 module, 15 text factsheets, 3 pictorial factsheets (Urdu and Sindhi) delivered to 121 households, 300 trainers, 50 VAs, 500 DVM students, 10 interns & 6 village Assistants	Project team
Case studies of existing service delivery to SR farmers	3.3	• Focus group discussions and qualitative assessment by farmers of existing service delivery & future needs for support for smallholder SR farming	216 respondents (125F + 91M)	Project team

Study	**Related Objective & Activity**[2]	**Aim, Study Structure & Key Measurements**	***Sample***	**Conducted by**
KAP and post-training surveys of impact of extension material on knowledge & farmer practice change	3.4	• Focus group discussions and post-training surveys of women & men farmers	1051 farmers	Project team

Other activities not listed in this table were covered by extension and engagement activities, which are described in Section 8.

5.5 Objective 1: Develop and test improved production practices to increase the growth and off take of small ruminants

This objective involved field surveys of SR production, marketing and health carried out at different scales. The largest studies in this Objective were a Regional Feed Survey conducted in 2018, and two randomised controlled trials of creep feeding conducted in 2019 (a pilot study using a commercial pelleted feed) and 2021 (a larger study using locally-available feedstuffs). All of these studies were conducted in agro-environments and farming systems qualitatively typical of smallholder SR farming in Punjab and Sindh.

5.5.1 Regional Feed Survey

The Regional Feed Survey involved 127 women and men from 114 households from 24 villages across 13 Districts in Punjab and Sindh (Figure 2). A questionnaire survey was used to collect information about kinds of fodder and feeds offered throughout the year, and a 1–5 score was assigned to each household to describe householders' perceptions of availability of land, fodder, energy/protein, degree of feed & water scarcity. The numbers of male and female adult and young (< 1 year old) SRs owned by each household at the time of interview and 12 months previously were recorded. From this, incidence rates (count per average number of breeding females on farm for the preceding 12 months) of births, deaths and animals reaching saleable age, plus associations with descriptive parameters in the survey were calculated.

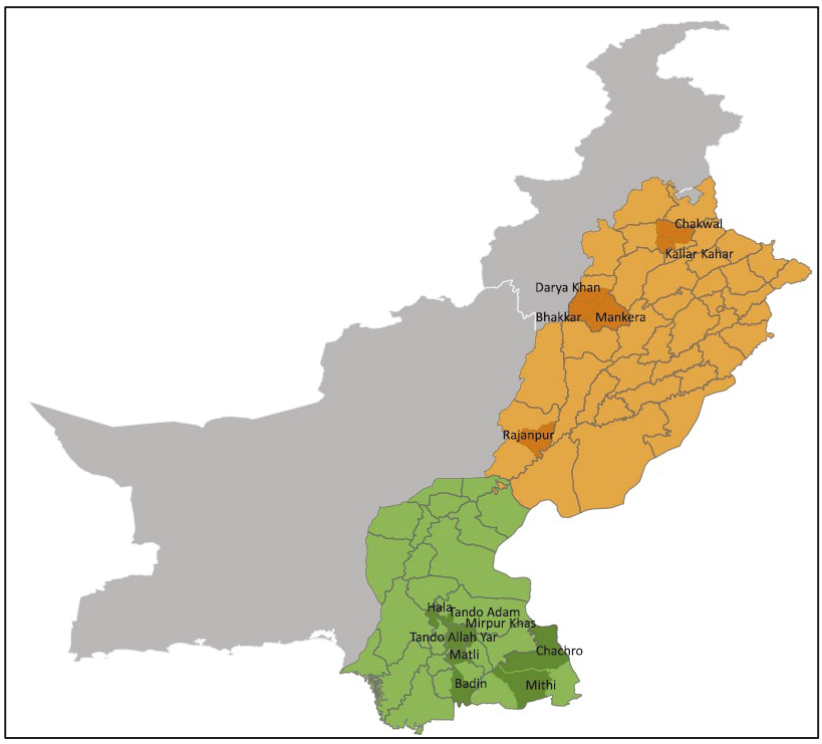

Figure 2: Tehsil (sub-district) locations of Regional Feed Survey interviews

5.5.2 Creep Feeding Trials

Two randomised controlled field experiments in multiple villages tested the effect of creep feeding young SRs in typical smallholder farming systems, a 'Pilot' trial in 2019 and a 'Local creep feeds' trial in 2020–21 (Figure 3). Both studies offered ~200 g/d (~1+% of bodyweight on a dry matter basis) of supplementary feed ~16–22% crude protein and >8

MJ ME/kg DM. For both trials, a visual guide was given to farmers to help them calculate the total amount of feed to offer to all young animals in the household each day (Figure 4). Bamboo creep barriers with 10 cm gaps between bars were built for each household and installed in animal pens (Figure 5). In households that did not normally pen animals, alternate feeding arrangements were used, such as offering feed to young animals when adults were out grazing or tethering young animals separately from adults and offering feed at that time.

In both trials, farmers randomised to the control group were given the same amount of supplementary feed as the treatment farmers at the end of the trial, so that households in both trial groups benefited equally by trial end. All households were provided with feeding buckets. The Pilot study involved treatment (creep feeding) households from one village and control households in a similar, neighbouring village. This study design was used to overcome the project team's concern that householders would not readily accept randomisation to the control group, although this confounded the design.

A widely available commercial feed, 'Wanda' (18–22% crude protein), was used in the Pilot study, which involved 36 households from four villages (two in each of Punjab and Sindh).

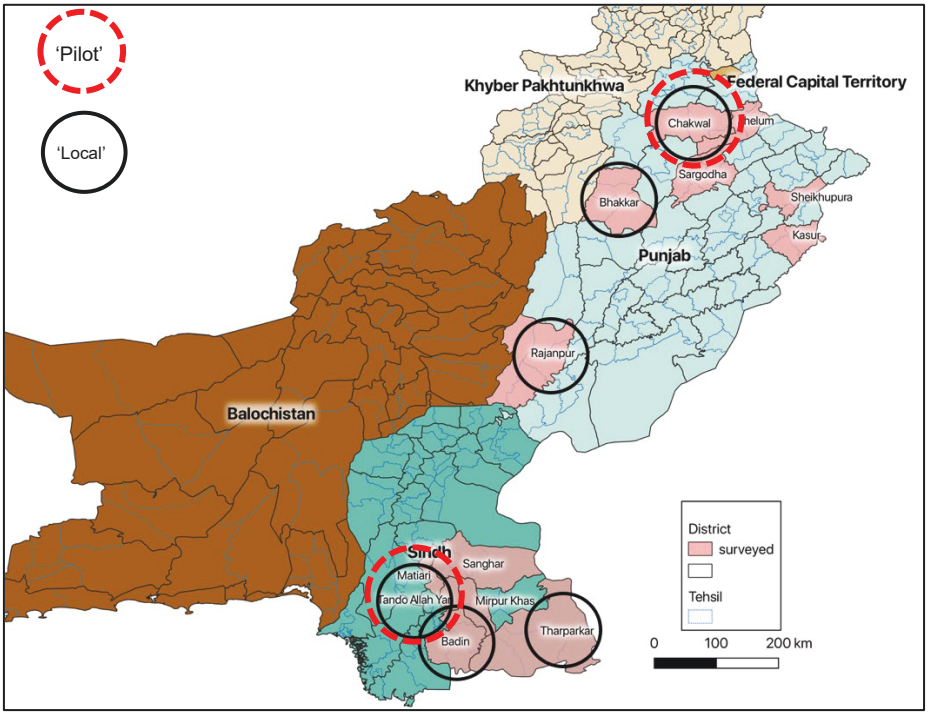

Figure 3: Locations of Pilot (2019) and Local Feeds (2021) creep feeding field trials

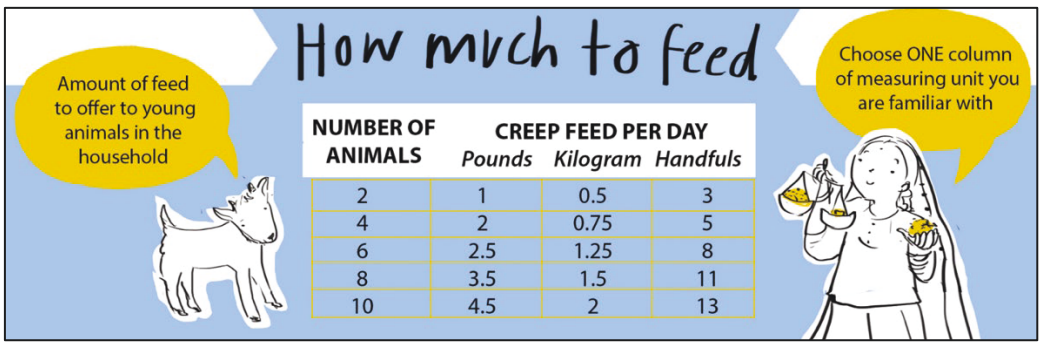

Figure 4: Farmer guide for quantities of supplementary creep feed to offer according to the number of young animals in household

Figure 5: Images of creep barriers; young goats and sheep will move through the bamboo posts to eat the feed and drink the water inside. Yellow arrow shows maximum width of gaps is 10 cm

The 2021 'Local creep feeds' study involved 121 households across 6 villages (three in each of Punjab and Sindh). Focus group discussions were conducted with women and men farmers before the experiment to identify feedstuffs fed to livestock in each village. From this, 1–2 feeds were selected for creep feeding, based on their nutritional quality (from typical proximate analysis values), availability in the village, and farmer experience of feeding them to livestock.

A third creep feeding activity was performed at the Sindh Livestock Department research farm at Dadu in central Sindh. Suckling kids were kept with their mothers under 'regular' management or creep feeding. Regular management involving daily grazing and supplementation of various cut-and-carry green fodder and crushed wheat. 'Creep' animals received these feeds as well as commercial 'Wanda' behind a creep barrier as described above.

At the end of both village trials, farmers were provided with visual reports describing the growth and other important production/health outcomes for their animals (Figure 6).

Figure 6: Example of farmer report card from creep feeding trial

5.5.3 Health monitoring

Routine health monitoring was part of the creep feeding studies, covering measurements of FAMACHA (anaemia) score (van Wyk and Bath 2002), faecal soiling of the breech ('dag'; Larsen and Anderson 2000), and specific diseases observed during monthly visits.

The Longitudinal Health Monitoring Study in 2020 was intended to additionally measure disease syndromes in household herds/flocks (Hanks *et al.* 2018), packed cell volume, total protein and worm egg count on bulked faecal samples from adult and young animals from each household. COVID-19 lockdowns meant that the study was only able to be conducted in one village, Bhurpur (Chakwal District, Punjab) for repeat visits. The first round of measurements (only) was performed in three villages in Sindh, Din Muhammad Kathio, Rakh Mankera and Saddiq Jatt. Serum samples were collected from animals at all these sites for subsequent serological analysis.

At the Bhurpur site, repeat measurements were made of liveweight, condition score, FAMACHA, packed cell volume and serum total protein, plus faecal samples for gastrointestinal parasite worm egg counts.

Where significant disease issues were reported or observed, the project team attempted to carry out a disease investigation including blood sampling, and liaised with local District Veterinary Officers to report results and treatment advice back to affected farmers.

5.6 Objective 2: Develop and test strategies small ruminant farming families can use to access market opportunities and attain market specifications

Note that the titles of Objectives 2 and 3 were incorrectly aligned with their actual activities in the original Project proposal. The activities listed in Objective 2 are related to SR value chains, and the activities under Objective 3 investigate family roles, benefits and engagement in SR farming. Compared to the original project proposal, the titles of Objectives 2 and 3 have been swapped so that they match the described activities more accurately.

Activities directly designed for Objective 2 were the ones most disrupted by COVID-19, as operation or access to livestock markets was stopped for extended periods in 2020 and 2021.The studies under this Objective involved a range of cross-sectional surveys conducted with farmers and people trading SRs in livestock markets. The study participants were usually a convenience sample of farmers from villages participating in other project activities or, in markets, people trading livestock, especially when animals were being traded prior to Eid.

The strategies that this Objective sought to evaluate were often interrelated to Objective 1 activities, or were developed based on Objective 1 observational or intervention study outcomes. For these activities, outcomes relevant to Objective 2 were assessed by conducting Knowledge, Attitude and Practice (KAP) surveys before and after intervention field trials to measure change in KAPs related to accessing market opportunities and attaining market specifications. Focus group discussions (FGDs) and training workshops were also conducted with women and men farmers in villages where project intervention trials were being conducted and where NGOs collaborating with the project were running their own activities. FGDs were used to describe constraints to market access and trading, and assess how the project's field interventions changed smallholder access to markets and livestock trading outcomes.

A before-and-after intervention study in multiple project villages was conducted to assess how providing farmers with weigh scales when trading livestock affected the success of trading. The effects of this intervention were measured with a questionnaire.

An observational cohort study was conducted of 300 SRs in lairage at a large metropolitan abattoir in Lahore. Information about origin and duration of transport was collected via a questionnaire, and pre-slaughter live animal characteristics, ante-mortem parameters and carcass traits were measured. A subset of 32 goats was randomly selected and samples of *longissimus lumborum* muscle analysed for pH, colour, water holding capacity and tenderness.

5.7 Objective 3: Identify and trial opportunities for women and their families to derive more benefits from small ruminant production and marketing

The KAP surveys described in the Objective 2 methodology above were used to describe the benefits and constraints SR farming offered to different household members, and the way these were affected by interventions tested in activities under this and other project Objectives.

Extension material was developed based on project team knowledge and existing resources relevant to SR farming in Pakistan (where available) or similar environments in other countries. Material was drafted and reviewed by the project team then tested with other local experts and trainers from collaborating NGOs and livestock departments, and small groups of farmers in project villages. The relevance and utility of the extension material was assessed using structured feedback questionnaires in one-on-one surveys conducted by the project team with farmers in their villages or attendees at 'Master Trainer' (i.e., training of trainers) sessions on the material content. Oral feedback surveys were conducted where required for low-literacy attendees. The feedback was used to update the extension material and Master Trainer training iteratively.

6 Achievements against activities and outputs/milestones

As described in Section 5, the project was designed so that activities and findings from some research studies supported multiple Objectives. For ease of interpretation, a brief description of key achievements under each research study is given below, followed by a more detailed description of how elements from these studies combined to support the project Objectives in Tables 2 to 4.

6.1 Impacts of COVID-19 on project achievements

Several important planned project activities were disrupted by COVID-19. The major longitudinal health monitoring field study that was set up in late 2019 had to be stopped because travel restrictions prevented the field team from returning to most villages to continue the study in 2020. Value chain research (Objective 2) was particularly impacted because activities under this Objective required both continued functioning of key value chain activities (e.g. livestock markets) and frequent team visits to villages to perform observational and intervention studies supporting improved value chain engagement. Neither of these was possible in most sites for from March 2020 until mid-2021. Major project activities under Objective 1 had already commenced prior to restrictions and were also significantly disrupted, therefore the project team gave priority to completing those studies.

A further complicating factor was that travel restrictions from Australia prevented Australian project staff visiting Pakistan to train the in-country team and collaborators for in-depth project activities. This affected the extent to which value chain and cross-disciplinary household studies could be performed because there was little existing in-country capacity in these areas. It also affected the project's ability to conduct detailed investigations and intervention trials for endemic and sub-clinical disease. Animal health research was further affected by rolling domestic travel restrictions, which meant that project staff were not in villages to investigate disease issues as they occurred, only learning about animal health problems months after the event.

Extra information on how COVID affected organisations and farmers was gathered through the COVID-19 stakeholder survey with organisations, the Births, Deaths, and Sales survey with farmers, and the Eid Marketing survey with farmers.

6.2 Overview of project achievements

The table below provides a summary of how specific aspects of each research study or major project component contributed to the achievement of project Objectives, Activities, and Outputs. Detail on participant numbers and locations can be found in Section 5 (Methodology) and results are elaborated in Section 7 (Key Results and Discussion).

Objective 1: Develop and test improved production practices to increase the growth and off take of small ruminants (40%)

Table 2: Achievements against Objective 1 activities

No.	Activity	Outputs/milestones	Completion date	Comments
1.1	**Test supplementary feeding strategies identified in the SRA***	**1.** Feed survey report	Y1, Q2	**Regional feed survey:** described structure, management, feed and resource availability, seasonal impacts and roles of different household members in SR management. Results reported at TropAg conference 2019 & used to inform design of subsequent feeding trials. *Materials available:* • TropAg 2019 conference abstract (Campbell, A.J.D. *et al.* 2019) • Detailed report on findings from Regional Feed Survey – includes feed calendars (available upon request)
		2. Identification of feeds that successfully improve growth (live weight), health (incidence of disease & survival) and gross margins in existing enterprises	Y2, Q2	**Regional feed survey:** Showed legume feeding associated with substantially reduced mortality in SRs. **Commercial feeds creep trial:** Creeping feeding using local commercially available feed (*Wanda*) improved growth and decreased mortality of young SRs at some sites **Dadu feeding trial:** Showed creep feeding with commercial concentrate (*Wanda*) improved weight gain for young SRs. **Local Creep Feeds Trial:** Showed supplementary feeding with locally available non-commercial feeds improved weight gain comparable to those achieved with commercial feeds. *Materials available:* • Regional feed survey report • Commercial feeds creep trial report • Local Creep Feeds Trial results (see Section 7.2.4.4) and paper (in preparation) • Results of Dadu trial (see Section 7.2.4.4)

		3. Report detailing some practical recommendations for feeding specific stock classes and specific production goals, including farmer decision support tools for choosing feeds for different goals	Y2, Q4	Project documented feeding recommendations through creation and dissemination of (instead of written report): Written and pictorial factsheets for farmers, Training modules & facilitator guides for factsheets (including creep feeding), Farmer workshops at beginning and end of the creep feeding trials, Presentations at the National Stakeholder Workshop Islamabad May 2022 See Section 1.1 for details of project dissemination activities. *Materials available:* • National Stakeholder Workshop presentation/s: https://research.aciar.gov.au/aik-saath/extension-module-and-factsheets-smallholder-farmers-and-staff-government-services-ngos-and-private • Farmer creep feeding factsheets (see https://research.aciar.gov.au/aik-saath/sheep-and-goats) • Facilitator training guide (see https://research.aciar.gov.au/aik-saath/sheep-and-goats) • *Wanda* feeding guidelines
1.2	**Identify and act on the key health and welfare issues for young and adult small ruminants**	**1.**Training material for research skills workshop	Y1, Q1	Rolling COVID-19 restrictions & other project work prevented the project hosting a formal research skills workshop; instead ran multiple research skills training sessions, including in-country applied training on longitudinal syndromic health monitoring; online training about on-farm disease outbreak investigation The team also engaged in collaborative research design activities with 9 MPhil student projects at UVAS and SAU *Materials available:* • Training slides and reference materials on blood collection, and bloodsmears, bovine haemotology, and piroplasms • Body condition scoring training slides, "How-to" sheet, and recording sheet • Animal syndromic health surveillance training slides and data collection protocol • Fecal egg count protocol • Weighing crate guidance for goats and sheep • Centrifuge operation, PCV and TP • Copy of surveys

		2. Report and information sheets detailing issues and best practice management strategies for health/welfare issues	Y3, Q1	**The following studies yielded and reported on data relevant to issues and best practices management strategies for health/welfare issues:** • **Regional feed survey:** Reported on mortality and production rates • **Commercial feeds creep trial**: Reported health and survival data • **Local Creep Feeds Trial:** Reported health, treatment, and survival data as well as farmer KAP on management and health. Local creep feeds trial also included questions to check for any hazard or risk to animal welfare posed by creep method. • **Longitudinal health monitoring** findings directly address key health issues, and findings informed reports and guidance provided to Sindh and Punjab livestock departments • **COVID19 stakeholder survey** collected data from 28 farms regarding challenges and mortality during the pandemic. Results are documented in the COVID19 Stakeholder Report. **The following information sheets and materials were produced:** • A comprehensive booklet on small ruminant management & health was produced and is available in Urdu, Sindhi, and English • 7 fact sheets on common small ruminant health problems were produced and are available in English, Urdu & Sindhi • 2 of these fact sheets were converted into a pictorial format for women with low literacy and are available in English, Urdu & Sindhi • Facilitator guides were produced to accompany pictorial fact sheets (creep feeding, diarrhea, brucellosis) for next-users, and are available in English and Urdu Language See Section 1.1 for details of project dissemination activities. *Materials available:* • Regional feed survey • Commercial feeds creep trial results • Local Creep Feeds Trial results (see Section 7.2.4.4) • Longitudinal health monitoring findings (see Section 7.1.3) • COVID19 Stakeholder report • Written factsheets • Pictorial factsheets and brochures, and Facilitator Guides (see https://research.aciar.gov.au/aik-saath/sheep-and-goats)
		3. A list of recommendations for future research around health and management		See Results and Impact sections of this report Recommendations were made at the National Workshop with sector stakeholders (May 2022) and Science into Action workshops, and UVAS forum *Materials available:* • National Workshop presentation pack (see https://research.aciar.gov.au/aik-saath/national-workshop-strategies-and-issues-pakistans-goat-and-sheep-sector) • Project final report and annexes

		4. Develop and present disease intervention case studies to relevant next users/implementers, including ways to collect, summarise, present and act on practical, relevant animal health field data (MTR Recommendation 2)	Q2 2022	**Disease intervention case studies:** • Four case studies of diseases observed during field work were produced, and health response notifications and summaries were sent to Punjab and Sindh Livestock Departments. • Mortality reports from COVID19 telephone data collection given to Punjab and Sindh livestock departments. **Resources on collecting, summarising, and presenting animal health data:** • The CommCare App and most CommCare surveys used for collecting animal health data in this trial are available for stakeholders to access and adapt to their needs • Project training materials are also available on feasible, field-friendly applied methods for monitoring animal health: BCS, FAMACHA, biosamples • A detailed protocol for longitudinal health monitoring, including guidelines for syndromic health observation, was produced and is available for adaptation. *Materials available:* • COVID19 Stakeholder Report • Disease case studies • Longitudinal Health Monitoring Exercise findings (see Section 7.1.3) • Animal syndromic health surveillance training slides and data collection protocol • Copy of surveys
		5. Develop policy briefing on Strengthening the quality and frequency of animal health data from the field into government departments and other agricultural programs. (MTR Recommendation 2)	Q2 2022	A policy brief on strengthening the quality and frequency of animal health data collection and sharing has been developed Project findings shared as part of the 2021 Data4Decisions 'solutions showcase', published at livestockdata.org Recommendations were made at the National Workshop with sector stakeholders (May 2022) *Materials available:* • Policy brief • Copy of surveys • Data4Decisions presentation (https://research.aciar.gov.au/aik-saath/sheep-and-goats) • National Workshop presentation (https://research.aciar.gov.au/aik-saath/national-workshop-strategies-and-issues-pakistans-goat-and-sheep-sector)

1.3	**Improving the survival and growth of young animals**	1. Report on young stock nutrition and management in controlled trial	Y2, Q2	See this report, including creep feeding trials results, MPhil studies, and National Workshop information pack **(**presented to 370 attendees in May 2022, and available online *Materials available:* • Commercial feeds creep trial report • MPhil abstracts
		2. Report on young stock growth and survival at a village and household level	Y3, Q2	See this report; Farmers received individualised report cards on their animals' growth, health and survival
		3. Best practice recommendations for improving young animal growth that are sensitive to the nutritional needs of farming families (do not negatively impact the amount of milk available for family use)	Y3, Q3	**Milk Use Survey** report describing current use of small ruminant milk by 173 men and 54 women, and showed widespread use of SR milk for household nutrition. This complements farmer recommendations on creep feeding Results of village trials presented & discussed with participating farmers; Knowledge, Attitude and Practices (KAP) surveys conducted to evaluate overall impact of creep feeding on household activities as well as animals; Presented in National Workshops Extension materials, presented and discussed with communities.
		* Develop a field guide for any organisations wanting to implement a form of creep feeding & share with relevant next users (MTR Recommendation 3)	Q2 2022	Small Ruminant Management & Health Handbook ('Module') Information sheets and facilitator guides/trainings on creep feeding Dissemination activities with NGOs, Govt departments, and Unis *Materials available:* • Copy of surveys • Facilitator guide and training module for female farmers; information sheets (see https://research.aciar.gov.au/aik-saath/sheep-and-goats)
		* Produce relevant and accessible extension material for male and female farmers on creep feeding, including the benefits and risks (MTR Recommendations 3 & 4)	Q2 2022	Training pack (facilitator guide & fact sheet) on creep feeding has been written in Urdu, Sindhi & women-focussed pictorial form and piloted with training organisations SR Handbook ('Module') *Materials available:* • Facilitator guide and training module for female farmers • Information sheets

1.4	**Conduct a creep feeding trial at the Sindh Livestock Department's Dadu Extension Farm**	Outputs associated with activity 1.3 (MTR Recommendation 3)		An on-station demonstration of using creep feeding in 46 young Kamori goats (< 6 months; 32 control + 14 treatment) was conducted over 6 months to estimate benefit:cost of creep feeding, including measurements of growth rate, survival, health status & feeding costs

Objective 2: Develop and test strategies small ruminant farming families can use to access market opportunities and attain market specifications (25%)

Table 3: Achievements against Objective 2 activities

No.	Activity	Outputs/milestones	Completion date	Comments
2.1	**Analyse how frequently the current value chain specifications for small ruminants are being met**	**1.** A report detailing price, profit discrepancies, incentives for improved performance for small holder farmers	Y1, Q4	*Materials available:* • 2018 Consumer survey data • Religious value chain consumer preference survey with results presented at TropAg international conference • Pilot rapid market assessment tool (CommCare) • Eid weighing trial data on estimated and actual weight, and impact on pricing • Dadu trial data on cost-effectiveness of commercial feeds
		2. A peer reviewed paper on carcass quality and disease status and the incidents and frequency of losses post-farm	Y2, Q2	MPhil student project on this topic completed; paper in preparation & results presented at 3 workshops/conferences.
		3. Baseline information that can be used to evaluate impact		Data described in 2.1.1 was used for design and comparisons of e.g. creep feeding trial results
2.2	**Trial strategies for better participation for men and women in small ruminant value chains**	**1.** Recommendations for value chain interactions that increase the benefits for stakeholders	Y1, Q3	Project team conducted Eid surveys in 2020 & 2021 with farmers in 2 districts of Punjab and 3 districts in Sindh to collect information on sale purchase and Eid value chain opportunities; results were presented in National Workshops & Final Report The Consumer Preferences and Religious Value Chain consumer surveys provided data on age, phenotypic features, price, and carcass weight preferred by consumers at local markets, who noted difficulty finding the product they preferred.
		2. Case studies of change following value chain engagement	Y3, Q1	~30 farmers participated in case study/qualitative trial at Eid 2021 to test how giving farmers access to scales to weigh livestock before selling affected trading practices; results were presented in National Workshop & analysed for Final Report

2.3	**Creep feeding approach adapted to Eid fattening demonstration activity (MTR Recommendation 3)**	1. A report on value chain opportunities for small holder farming families	Y1, Q4	*Materials available:* • Eid weighing trial • Religious value chain consumer preferences survey • Eid marketing survey has data about pre-Eid extra feeding practices Further observational studies were not done due to COVID-19 interruptions & prioritising other project activities
		2. Case studies of change following value chain engagement	Y3, Q3	Qualitative farmer reports of effect of creep feeding on Eid sales has been collected, and presented as part of National Workshop

Objective 3: Identify and trial opportunities for women and their families to derive more benefits from small ruminant production and marketing (35%)

Table 4: Achievements against Objective 3 activities

No.	Activity	Outputs/milestones	Completion date	Comments
3.1	**Develop a deeper understanding of the value small ruminants have to men, women and youth in farming families, and the empirical knowledge of different family members for nutrition, management and health, including zoonotic disease**	**1.** Training material for research skills workshop	Y1, Q1	Several research skills capacity building events were held, and training materials for most are available: • Joint session with Dairy beef team on online scientific writing tools • Two project team members attended a 9-day digital data collection training (CommCare) in Vietnam • Collaborative research design activities with 9 MPhil student projects at UVAS and SAU • DVM Interns were mentored to complete five short research projects designed to develop their research skills (Ethical research, Smallholder markets, Market development, Smallholder market participation, Integrating smallholders into markets) *Materials available* • Copy of surveys
		2. Baseline report that can be used to evaluate impact	Y1, Q4	*Information gathered from multiple sources:* • Knowledge, attitudes & practices (KAP) surveys before and after creep feeding trials: • Household registration surveys provided baseline and endline data on knowledge of a range of areas related to SR management, household & gender roles, decision-making, and information on contribution of SRs to livelihoods • Milk Use Survey also provided information on value of SRs to households & consumption of SR products • An MPhil thesis provided data on attitudes & understanding of women & men to zoonotic disease and related practices • COVID19 Births, Deaths, and Sales and 2020 Eid Marketing surveys provided data on men's and women's ownership of animals brought to market, contribution of SRs to household livelihoods, prices gained from selling at Eid, and use of extra income
		3. Peer reviewed paper	Y2, Q2	MPhil thesis on attitudes & understanding of women & men to zoonotic disease completed & journal paper in preparation

3.2	**Create material that addresses key knowledge gaps in nutrition, management and health that is targeted to men, women and youth in small ruminant farming families and different types of farming systems**	**1.** Report on new information sharing approaches	Y1, Q1	See this report, covering: • Pictorial fact sheets for information-sharing for low-literacy women & men prepared & tested; reported on at National Workshops & Final Report • Use of demonstration farms • Data from control and spillover families' uptake of creep feeding • Training sessions on health and management topics • Semi-structured information sharing calls with key next-users
		~~**2.** Workshop report Y1, Q2~~		Included in error; removed at Mid-Term Review
		3. Extension materials that are grounded in research and inclusive of the needs of all members of small ruminant farming families	Y2, Q1	See this report for discussion of effective approaches
3.3	**FGDs & surveys about farmers' needs (MTR Recommendation 4)**	**1.** Develop case studies and policy plans around Farmers' needs & case studies of delivering more effective support	Q2 2022	Reports on farmer access to services during COVD-19 lockdowns provided to Punjab & Sindh Livestock Departments Case studies & farmers' views about need for services & information collected in March 2022 during Village Workshops; Results & implications were presented in to key national stakeholders during National Workshops (Islamabad, May 2022) & Final Report Policy brief on includes recommendations based on the above for creating better links between LDs, service providers, and farmers
3.4	**Trial ways to share extension messages to address the needs of families raising small ruminants and next users (MTR Recommendation 4)**	**1.** Qualitative and quantitative data on information sharing approaches and their impact on practice change	Y3,Q1	Numerous Provincial and National Dissemination events – see Section 8.4 plus: • Trainings and FGDs – feedback gained from participants • Pictorial factsheets and women's training module which presented information through analogies relevant to women's frames of reference (and iterative design approach) • Organisational stakeholder feedback on use & design of extension materials • KAP and post-training surveys conducted to assess impact on knowledge-sharing & farmer practice change of pictorial fact sheets and participatory approach to creep feeding • Info sharing with LDs, e.g. sporadic health observations/responses, COVID19 Births, Deaths, Sales mortality summary.

		2. Training package on tools for scale out organisations	Q2 2022	Facilitator guides for key topics including how to use pictorial fact sheets & other non-traditional approaches to knowledge sharing have been written & drafts tested with next-users; showcased in National Workshops Module facilitator guide Incorporation of BCS and creep feeding training into vet school curriculums

7 Key results and discussion

7.1 Existing SR management and household member roles

Strategies to increase SR offtake and profitability of smallholder farms, and attain market specifications require a clear understanding of current farm practices, production and profitability. They also require an understanding of existing constraints and potential opportunities within current practices and resources. Building on preliminary qualitative results from the SRA, several activities conducted under our three project Objectives quantified these elements and informed the type and value of interventions that can sustainably increase production and smallholder net income. Relevant results from Objective 1, 2 and 3 activities are synthesised and presented here.

7.1.1 Typical SR herd/flock structures

The Regional Feed Survey of farmers across Punjab and Sindh (see Figure 2, page 16) showed that most smallholder households raising SRs kept goats, although 24% of households kept both goats and sheep (Figure 7). Most smallholder SR farms in Punjab and Sindh were 'self-replacing' herds/flocks comprised of breeding females and males, plus offspring that are sold opportunistically when a household needs income. Median breeding herd size was 6 does or 7 ewes per household, and 25% of households had 4 or fewer breeding females. Farms with both goats and sheep kept a median of 16 does and ewes, about three times bigger than single-species enterprises ($P < 0.05$).

7.1.2 Management roles and value of SRs in rural smallholder households

A range of results from Objectives 1 and 3 described the importance of SRs to women, men and youth, both as a source of income, and for home use of milk and meat products. We also present information about the roles of different family members and opportunities to deliver greater benefits to them through changed SR management.

In the Regional Feeds Survey, most households reported that members of the extended family (especially men) were involved in SR feeding management. It was uncommon for families to hire someone to feed or supervise small ruminant grazing (11% in Punjab and 24% in Sindh). Women were responsible for the care of young SRs in a very large majority of households: 93% and 82% of households in the Regional Feeds and Local Creep Feeds Trial surveys, respectively. Women were also responsible for grazing management or had a greater management role in 37% of Sindhi households in the Regional Feed Survey.

Largely, multiple family members were involved in decision-making regarding small ruminant management. However, men had sole control over how income from SRs was used in the majority of households in all survey areas (Table 5). Where information was collected, income from small ruminant production was most commonly used for general household expenses (73%) followed by agricultural purposes (46%) such as buying feed and livestock. Other

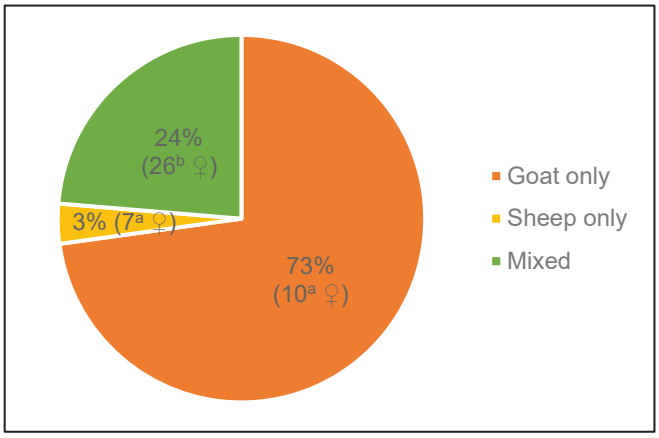

Figure 7: Proportion of farms keeping does &/or ewes (average number of adult females). ***Different superscripts show significant differences in number of adult females (P < 0.05)***

uses included family medical treatment (27%), clothes (26%), ceremonies such as marriages (23%), and for household emergency expenditure (13%).

On average, selling SRs for meat accounted for the highest proportion of total income (46%; Table 6). Labour contributed on average 39%, and crops 33%. Neither milk from small nor large ruminants was a frequent source of income in this survey sample (even among the 29% who sold large ruminant meat), suggesting it was mainly used for home consumption. Between 69% and 88% of SR-owning households in the Regional Feeds Survey and Local Creep Feeds Trial reported consuming milk from SRs. Of the latter, most households both consumed milk themselves and provided it to kids and lambs (Figure 8). Of Local Creep Feeds Trial participants, only 48% consumed meat from SRs they raised.

Over half of all sheep-owning households and more than two thirds of goat owning households said that they kept these animals for milk purposes, including direct use or sale of milk for household profits. This affirms the importance of goat and sheep milk for family nutrition purposes, either directly or indirectly. It was commonly described by families to give milk as a priority to young stock, and then utilize the remaining milk for making tea, yogurt, buttermilk and yogurt milk, and also give to their children for drinking.

Table 5: Decision-making power and income control in SR-owning households

	Decision-making power			Control over income			
	Male farmer only	**+ other men**	**+ family/ women**	**Male farmer only**	**+ other men**	**+ women**	**+ family**
Punjab	*13.7%*	*15.7%*	*68.6%*	*64.7%*	*27.5%*	*11.8%*	*2.0%*
Chakwal	3.6%	21.4%	75.0%	64.3%	28.6%	3.6%	0.0%
Bhakkar	46.2%	15.4%	38.5%	53.8%	30.8%	15.4%	7.7%
Rajanpur	0.0%	0.0%	100.0%	80.0%	20.0%	30.0%	0.0%
Sindh	*23.8%*	*6.3%*	*60.3%*	*85.7%*	*4.8%*	*7.9%*	*7.9%*
Badin	0.0%	11.8%	88.2%	82.4%	5.9%	17.6%	0.0%
Matiari	60.0%	0.0%	40.0%	80.0%	0.0%	0.0%	20.0%
Mirpur Khas	25.0%	25.0%	50.0%	100.0%	0.0%	0.0%	0.0%
Sanghar	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%
Tando Allahyar	29.2%	4.2%	41.7%	83.3%	4.2%	4.2%	4.2%
Tharparkar	44.4%	0.0%	55.6%	88.9%	11.1%	11.1%	33.3%

Table 6: Income sources and proportional contribution to total household income in SR-owning households (SR: small ruminant; LR: large ruminant)

Livelihood source	Number (proportion) making livelihood from source	Average % of total livelihood from source (SD)*
SR meat	121 (98%)	46.2% *(17.1)*
Crops	81 (66%)	32.8% *(14.4)*
Labour	51 (41%)	38.7% *(15.8)*
LR meat	36 (29%)	30.0% *(11.3)*
Other	14 (11%)	38.6% *(16.1)*
LR milk	6 (5%)	26.7% *(12.1)*
Shop	5 (4%)	40.0% *(10.0)*
SR milk	3 (2%)	25.0% *(7.1)*
Remittances	0	-

** Means taken only from respondents who reported receiving some livelihood from this source*

Overall, 55% of households in the Zoonotic Disease Survey (see Section 7.3) consumed raw SR milk and/or milk products, and 44% consumed it daily (Table 7). Householders considered unpasteurised milk to be “more nutritious and healthier”, especially for children. Listeriosis was nominated as a disease affecting interviewees’ animals, as was brucellosis, making this practice risky to the health of all members of the household. Most interviewees in the Zoonotic Disease study said they give goat milk to their children because it is a good source of nutrition and believed it was healthier for them. Families that owned large ruminants sometimes still fed children goat milk because they believe it was more easily digested than milk from large ruminants.

With over 50% of people surveyed describing milk as one of the reasons they kept small ruminants, and almost 70% of respondents using milk from small ruminants for their household, it can be considered a staple of the household. Milk from goats and sheep is likely proportionally more important to some vulnerable groups, specifically resource-poor households or regions, and to children. Encouraging any change around how goat and sheep milk is used could have negative production, human nutrition and economic impacts for families. Although opportunities for using goat and sheep milk as a value-added product may be possible for some households, the implications for households need to be strongly considered before this could be considered as a wider-scale option. If this was to be a value chain opportunity for promotion, it could be done sensitively by including a decision-making tree that included assessment of young stock growth and survival, and household reliance on milk.

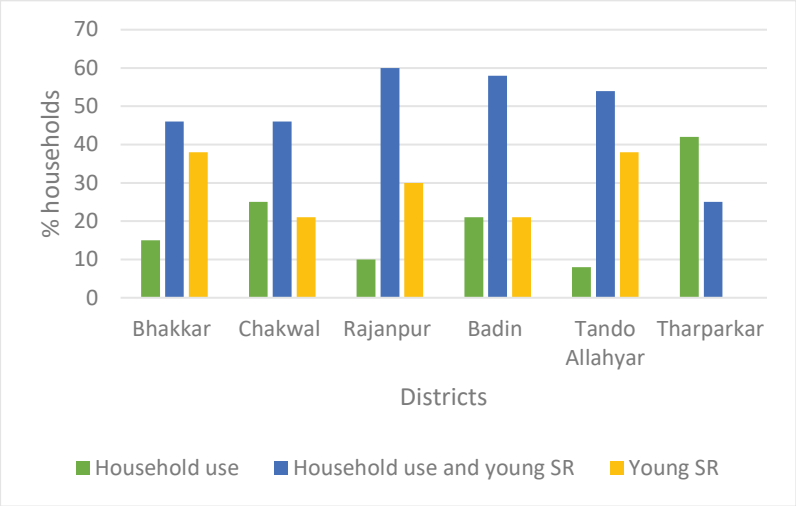

Figure 8: Proportion of households using milk from SRs for different purposes in Districts in Punjab and Sindh

Table 7: Uses of SR milk by households in Punjab and Sindh (from Regional Feeds Survey)

	Women	Men
Total respondents	49	72
Use raw milk	23 (47%)	52 (72%)
Consume raw milk daily	16 (33%)	37 (51%)
Dispose of ‘diseased’ milk	38 (78%)	34 (47%)
Agree raw milk is healthier	30 (61%)	34 (47%)
Agree that giving raw milk to children is healthy	27 (55%)	45 (63%)
Households where goats kept for milk	35 (73%)	44 (64%)
Households where sheep kept for milk	7 (50%)	19 (56%)

7.1.3 Management and supplementary feed use by smallholders

The Regional Feed Survey across Punjab and Sindh (see Figure 2, page 16) provided detail about how smallholder SR farmers manage the nutrition of their herds/flocks. Most (88%) farmers grazed animals on common areas around their villages but used a very wide range of supplementary feeds throughout the year in different ways. Animals were grazed for an average of 7.6 hours/day, with slightly longer time in summer than winter.

A very wide range of additional feeds was used by farmers, including concentrates (e.g. grains), dry and green fodder, grazing of post-harvest residues of various crops, and crop by-products (including husks, straws and processing waste; Figure 9). There were large variations in the use of supplementary feed within and between districts. Grazing of natural grasses was more common in Chakwal and Bhakkar, whereas Rajanpur farmers more commonly fed cut-and-carry grasses and forages. Chakwal farmers used the widest variety of concentrate types (15), whereas farmers in Bhakkar and Rajanpur used a much smaller variety of concentrate types (6-7). On average, Punjab farmers used 3, 1.3 and 2.7 different concentrate types per respective districts. Some feeds were used for targeted feeding of specific stock classes, although this was confined to specific farms and not widely practised across all survey areas. For example, cottonseed cake (the by-product of cotton oil processing) was the most common concentrate given to small ruminants in Punjab (73%, n=37) and was usually fed to animals for a few months relating to specific animal conditions such as pregnancy, post-parturition, milking, in preparation for Eid, dependant on availability. The most common supplementary feeds used by Sindhi farmers were forages and crop stubbles. Concentrates were not widely used, although wheat bran was fed by 41% of Sindhi farmers. Forages were more commonly used cut-and-carry rather than directly grazed.

In total, there were 1200 reports of feeds used across the 13 districts surveyed. On average 100 different types of feed were used per district. Detailed feeding calendars were developed, showing the seasonal use of feed resources, where gaps exist, and the kinds of local feeds that can be used to fill them. These are provided for each District covered by the survey and available in the Regional Feed Survey full report.

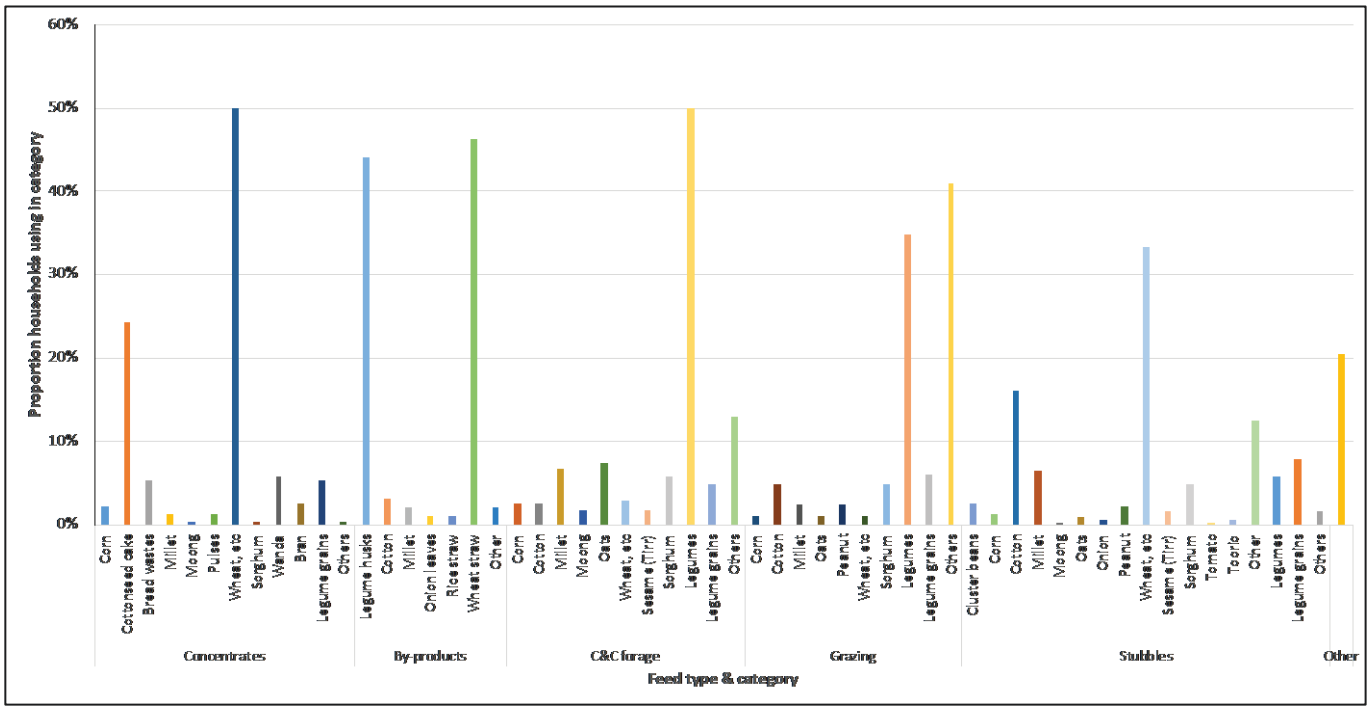

Figure 9: Proportion of households feeding different kinds of feed categories and feeds to small ruminants in Punjab and Sindh

These results show that there is significant potential offered by the feed resources that are locally available to farmers, and that some farmers are used to purchasing feed for SRs. On the other hand, farmers reported that feed availability was an important constraint to successful SR production (Section 7.2.1). In the face of such an array of available feeds, this opinion of farmers suggests a disconnect between the physical resources typically available in villages and the ability of farmers to effectively use them. This is reinforced by the relatively low proportion of SR farmers reporting actually using feeds that they nominated as being readily available in their village (Table 8). The apparent under-utilisation of feeds, despite their wide availability, may be due to a range of factors, such as a lack of guidance, experience or confidence in targeting feeds to particular stock classes, an inability to store particular kinds of feeds, or price or availability at critical times of the year.

Other organisations working with smallholder SR farmers should be aware of this situation, and that a range of feeds is often locally available to farmers, even if awareness about their use is not widespread. If livestock departments, NGOs and similar organisations are running programs to improve the way farmers feed their sheep and goats, taking the time to understand what local feeds are available and including these in feeding recommendations and strategies will likely introduce efficiencies and production improvements into local farming systems.

Similarly, in some situations investing development money in buying local feeds for farmers to give their animals might be more useful than investments in other development activities such as buying livestock for beneficiary households. This obviously depends on the local situation, but it is worth considering these available local resources and how using them can support goat and sheep farmer livelihoods.

Table 8: Proportion of farmers reporting using different kinds of feeds prior to creep feeding field trials

Nutritional quality category	Feed type	Number using	Total interviewed	Proportion using
Low	Chickpea straw	35	38	92%
	Jawar straw	0	38	0%
	Millet fodder	0	40	0%
	Oat straw	2	38	5%
	Peanut husk	6	38	16%
	Rice straw	5	153	3%
	Wheat straw	78	231	34%
Low sub-total		**126**	**576**	**22%**
Intermediate	Peanut straw	32	38	84%
Intermediate sub-total		**32**	**38**	**84%**
High	Berseem	99	193	51%
	Chickpea grain	7	38	18%
	Cottonseed cake	60	231	26%
	Cowpea	1	40	3%
	Cowpea straw	12	38	32%
	Jantar	87	193	45%
	Lucerne	36	153	24%
	Millet grain	3	40	8%
	Oat fodder	0	40	0%
	Wheat bran	99	231	43%
	Wheat grain	39	76	51%
High sub-total		**443**	**1273**	**35%**

7.2 Areas of loss and opportunities for improvement

7.2.1 Farmer-reported resource constraints

The project identified and categorised constraints to SR production in a variety of ways because there is little holistic information about this for smallholder farming in Pakistan. The proportion of farmers reporting constraints affecting their SR farming in the Regional Feed Survey is shown in Figure 10. The most widespread constraint reported was insufficient fodder, with 44% (95% CI 38–51%) of farmers reporting this as an issue. This was a significantly ($P < 0.01$) greater proportion than for other constraints. After fodder shortages, 19% of respondents identified animal health issues as important constraints, although this was similar to proportions concerned about water availability, access to finance and weather impacts on livestock rearing.

Unsurprisingly, some constraints were more important in particular areas. The Regional Feed Survey also included project staff scoring village resource constraints at the end of the Survey's qualitative interviews. Water availability was a severe constraint in drier seasons. The general availability of fodder was a more important issue than feed quality (implied by the energy/protein resource allocation) or quantity deficits. This potentially indicates a disconnect in farmers' understanding of supplementary feeding requirements of livestock, since fodder supplied from outside the farm presumably is required to fill feed quantity and/or quality gaps. Nonetheless, about half of farmers reported a moderate deficit in feed availability in poorer seasons, which will likely especially affect breeding and growing stock.

In addition to physical resources, famers were surveyed in several different settings about the role of services in their SR farming. Up to 40% of households interviewed in the Regional Feed Survey reported having no veterinary support from any source, with Sindhi households having less support in particular (Table 9). Conversely, more farmers in Sindh reported receiving training in animal health care, although it was still a minority, encompassing only 10% of households across the two provinces.

In the 2021 SR Marketing Practices at Eid survey, farmers indicated that improved access to most proposed services or knowledge would help make trading SRs at Eid or other times more successful (Table 10). There was no difference in the frequency of different factors being reported as 'Very useful' ($P = 0.9$), with average scores of 1.5–1.9 out of 2. This broad desire suggests a current lack of services that particularly support the ability of farmers to sell their SRs successfully.

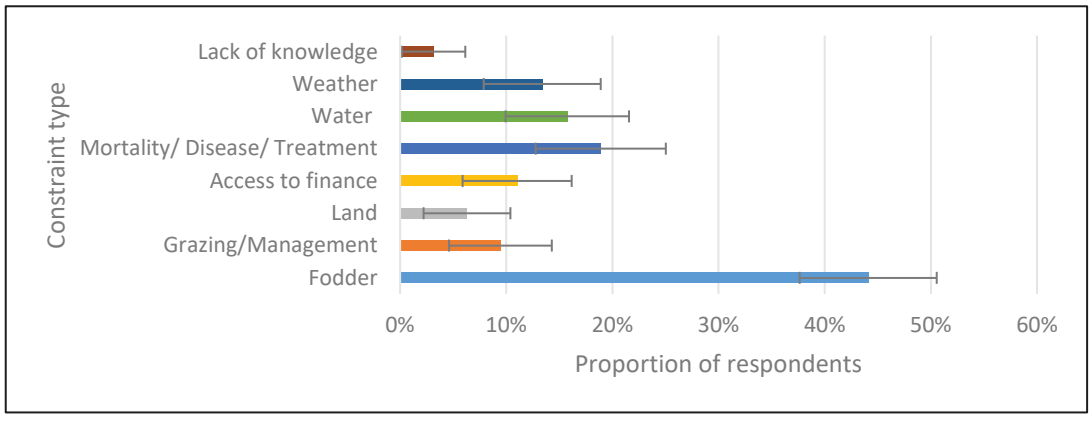

Figure 10: Proportion of farmers reporting different kinds of constraints to SR production (error bars: 95% confidence interval)

Table 9: Proportion of farmers receiving different kinds of veterinary support in Punjab and Sindh

Province	Veterinary Support				Animal Health Care Training
	Government	Private	Other source	None/self	
Punjab	47%	57%	0%	8%	6%
Sindh	5%	29%	29%	40%	14%
Combined	*24%*	*42%*	*17%*	*25%*	*10%*

Table 10: Reported usefulness of different services for improving SR selling

Resource type	Average score (95% CI)*
Better feeds	1.52 (1.36–1.69)
Better feeding knowledge	1.67 (1.48–1.85)
Better price information	1.56 (1.38–1.74)
Better access to traders	1.83 (1.72–1.95)
Better transport for SRs	1.83 (1.72–1.95)
Access to different breeds	1.91 (1.82–2)
Better access or knowledge about treatments	1.92 (1.83–2)

* *Average of 0–2 scale of* no value…somewhat..very useful

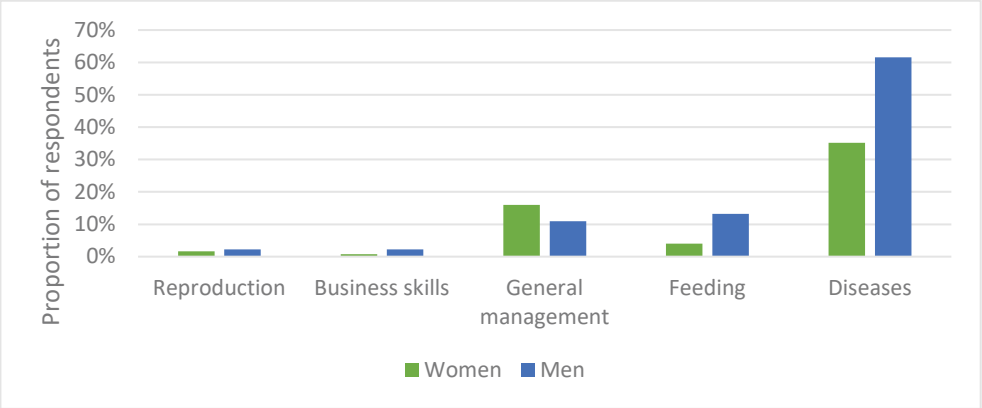

Figure 11: Proportion of farmers attending post-local creep feeds trial meetings requesting further training in different topics in SR farming

Women farmers often do not receive training and extension information due to social and cultural norms. Saghir *et al* (2014) found female farmers in Pakistan to be deficient in knowledge about neonatal care of small and large ruminants, largely because they do not have access to information. Although rural women had a productive role in SR management and were interested in receiving training, they did not receive adequate advice or have adequate access to technology that could benefit them in their livestock management activities. Women have less direct contact with animal health providers, most of whom are male, which has important implications for how we could advise women to seek animal health advice and provides a clear need for increasing the capacity and availability of female animal health workers.

Farmers from villages where the Local Creep Feeds Trials were conducted (n = 216) identified that additional training in livestock disease was particularly desirable, suggesting that smallholders continue to have an unmet need for knowledge about animal health (Figure 11). This survey took place after workshops for women and men about the effects of creep feeding, which had just been trialled in their village. The relatively low proportion

of people (<15%) wanting further training in feeding suggests that participation in the trial had increased confidence in feeding management. However, despite working intensively with the project team and discussing health issues on an ad hoc basis during trial visits, the high demand for animal health training reflects the ongoing impact that diseases have on SR production, as described in more detail in the following sections.

7.2.2 On-farm mortality and reproductive loss

Poor survival and reproduction were a significant issue in all areas in Punjab and Sindh where the project worked. This was verified in multiple ways. Incidence rates for births and mortality calculated from the Regional Feed Survey are listed in Table 11 and show that both mortality and poor reproduction severely limit herd/flock productivity on many farms. Annual doe/ewe mortality was 0-15%, and four villages reported average doe mortality >14%. Comparable mortality of 11% across village monitoring sites in Punjab and Sindh was observed over a 3-month period in early 2020, with 40–75% of monitored farms having some livestock die in that time (Table 12). Similarly, at the start of the creep supplementary feed intervention trial in late 2020, in the preparatory household surveys farmers reported an average of 17% of young and 9% of adult SRs had died in the previous year.

A range of causes were proposed by farmers and local animal health workers, including diarrhoea, peste des petits ruminants (PPR) and infectious pneumonia, although no diagnoses were ever confirmed. This occurred during the first wave of COVID-19

Table 11: Annualised birth, rearing to 1 year old and mortality rates on smallholder small ruminant farms in Punjab and Sindh

Indicator*	Stock class	Average (95% CI)	Village range
Birth rate (per breeding female)	Kids/doe	0.9 (0.8–1.1)	0.2–1.8
	Lambs/ewe	0.4 (0.2–0.5)	0–0.8
Offspring reared per breeding female	Kids/doe	0.8 (0.7–0.9)	0.2–1.4
	Lambs/ewe	0.3 (0.2–0.5)	0–0.7
Mortality	Breeding females	8.9% (4.6–13%)	0–20%
	Young goats	19% (14–24%)	0–49%
	Young sheep	6.0% (0–12%)	0–33%

* annualised

Table 12: Mortality in first three months of 2020 reported in 38 households in four villages in Punjab and Sindh

	Village (*n* households surveyed)	Household counts				% HHs with deaths	Comment
		Goats	Sheep	Total	Mortality[5]		
Punjab	Bhurpur (10)	171	83	254	16%	60%	Varying signs in mortality cases including diarrhoea & respiratory symptoms; advice to some farmers from local vets suggested PPR as differential diagnosis
	Rakh Mankera (10)	95	161	256	14%	40%	Various signs in dead animals, including lung changes; suspected ruminal acidosis in one household
Sindh	Din Mohammad Kathio (8)	207	7	214	10%	75%	Diarrhoea & respiratory symptoms in affected animals
	Sadiq Jatt (10)	182	40	222	18%	40%	Respiratory symptoms ('flu') and sudden death in affected animals

[5] *Median for all households surveyed, including those reporting zero deaths*

infections and movement restrictions in Pakistan, when farmers reported that both public and private veterinarians were unable to visit villages and veterinary supplies stores were closed. It is difficult to assess how much this contributed to the impact of these disease outbreaks, but anecdotally similar impacts were seen after movement and services returned to more normal conditions after 2020 (see disease outbreak descriptions presented below in Table 13, page 43). This suggests ineffective management of disease by farmers and/or animal health workers is common on SR farms.

Herd/flock reproductive efficiency was also generally low, and appeared to involve a combination of low birth rates and poor survival of young stock, depending on location. Although two villages reported average birth rates >1.5 kids/doe/year, it was <1 kid/doe/year in 11 (46%) villages. Reported kid mortality was often high, ≥10% p.a. in 14/24 villages, including 6 villages >20% (maximum 36%). These effects reduced production of saleable offspring. In 58% of villages, average production of 'saleable' offspring was <1 animal per breeding female per year, and no villages produced >1.5 saleable offspring/breeding female/year. This is a significantly low figure, given that many goat breeds will conceive two offspring per year.

These figures show that poor productivity is cumulative, with likely multifactorial causes contributing to poor conception, and high offspring & dam mortality. Improving overall conception and survival would reduce significant wastage, substantially improve household income from existing livestock holdings, and meet untapped national demand for goat and sheep meat.

This simple assessment methodology has been demonstrated to efficiently assess productivity using stock tally figures that many farmers can readily supply to investigators. In turn, this benchmarking can help identify areas of loss to target further investigation and interventions.

The Regional Feeds Survey identified links and potential solutions between SR feeding and mortality. In the survey, farms where leguminous feeds were offered to SRs had 42% lower mortality (mortality incidence 10 deaths/100 head/year) than households that did not use leguminous feeds (18 deaths/100 head/year; $P < 0.01$). The population attributable fraction of not feeding legumes was 22%. This says that, statistically, 22% of all mortality observed across all survey households could be avoided if legume feeding was used. This shows how important offering feeds of the appropriate quality could be in improving livestock survival on SR farms.

7.2.3 Body condition score as a measure of productivity

The issues described above—nutritional resource constraints, poor survival of young animals and poor reproduction by breeders—are likely to be strongly inter-related, with the former a primary cause of the latter (Campbell *et al.* 2009; Campbell 2010; Glanville *et al.* 2017). We measured the direct impact of nutritional constraints by assessing the body condition score (BCS) of SRs across four village sites in Punjab (n=2) and Sindh (n=2) at the start of the Longitudinal Health Monitoring study. BCS was generally very poor in late 2020/early 2021 at the start of monitoring (Figure 12). At this time, ≥67% of adult goats were very thin (BCS <2 out of 5). Adult sheep were similar at all but one site (data not shown), suggesting this problem and its sequelae are widespread in both goats and sheep on smallholder farms.

Ongoing monitoring of animals in one of these villages (Bhurpur village, Punjab) showed poor body condition continued to be widespread in adult goats and sheep. There was only modest improvement in BCS throughout the year, with at best only 18% of goats having BCS ≥ 2. Sheep did improve to a greater extent, rising from a nadir of 23% in BCS ≥ 2 to 75% in both December and September (Figure 13). This has serious implications for the efficiency of farm production, reproduction and survival, and should be a focus of more detailed investigations to verify the relative contributions of feeding, husbandry and disease, and practical interventions to address this issue.

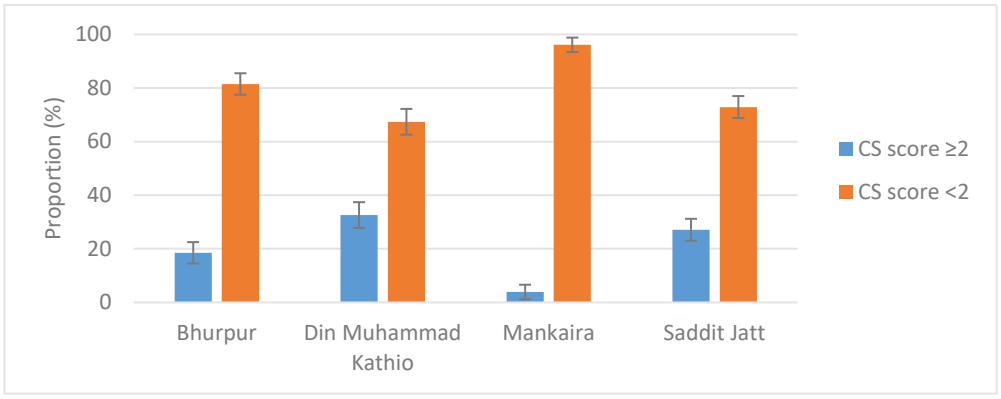

Figure 12: Proportion of adult goats in very thin body condition (BCS<2) in 4 villages in Punjab and Sindh in December 2019

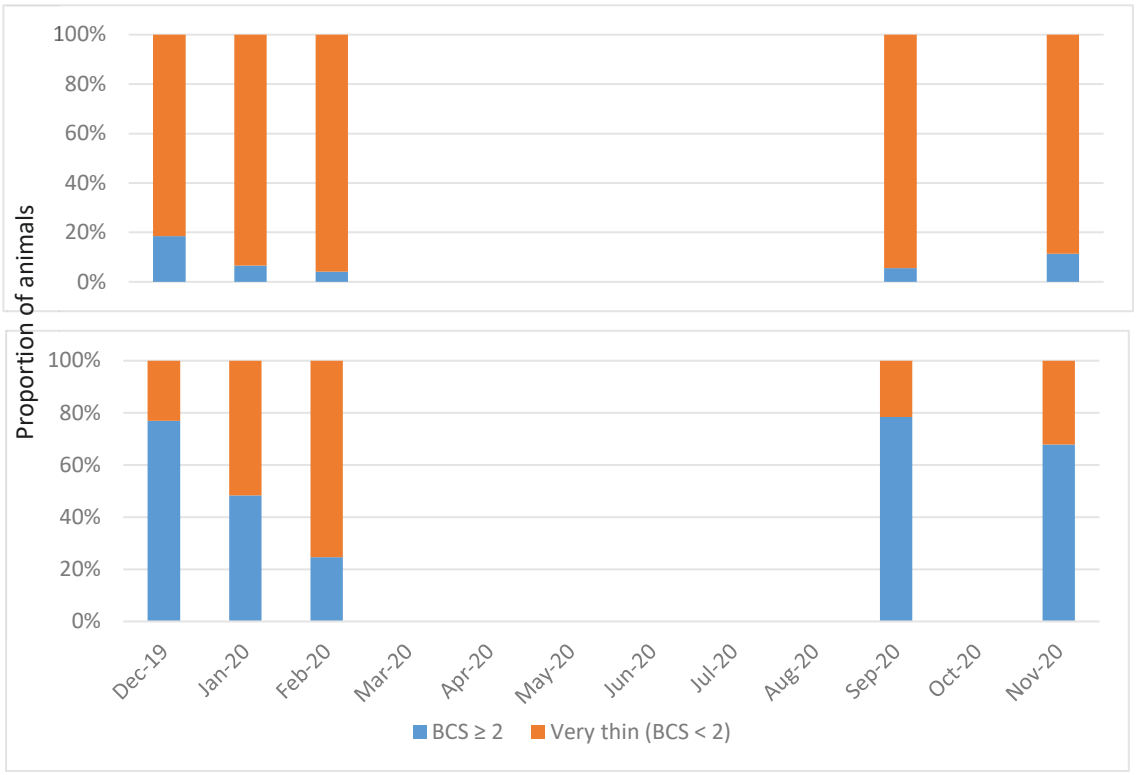

Figure 13: Proportion of adult goats (upper) and sheep (lower) in very thin body condition (BCS<2) in Bhurpur village, Punjab December 2019–November 2020

BCS is straightforward to measure, and farmers and advisors can be trained to use it effectively. Farmers trained in BCS considered it useful, scoring it 4.9 out of 6 (see Section 8.2). Farmers trained in BCS made comments such as, "*We used to select animals on the basis of physical appearance but we never knew or saw this BCS technique before. It is a new and technical skill for us.*"

Other health issues were present throughout this time (see Table 12) that may have contributed to this extensive poor condition. However, animals in fatter body condition are more resilient to disease (Campbell 2010), so improving nutrition is likely to both directly improve BCS (Morand-Fehr 2005) and mitigate the adverse effects of disease, improving productivity overall. Similarly, this work did not identify the cause(s) of poor reproduction, which could include the direct effects of under-nutrition, infectious disease or (less likely) climatic effects on survival of newborn and young animals.

7.2.4 Key health and welfare issues for young and adult small ruminants

This section presents results of the project's observational studies into SR health. These studies have provided important information about the effects that different kinds of animal health issues—and current approaches to managing them—have on the productivity and sustainability of SR production by smallholder farmers.

7.2.4.1 Importance of 'outbreak' and endemic, sub-clinical diseases

Information reported in this section strongly suggests that SR farming is threatened by a combination of 'outbreak', and clinical and sub-clinical chronic diseases. Outbreak diseases seem to receive relatively more (but still little) attention, whereas other conditions are almost entirely overlooked despite causing significant production and livelihood loss.

This situation is reflected in several case studies from the project. The mortality case series presented in Table 12 (page 40) shows a mixture of 'outbreak' diseases such as PPR; diarrhoea (likely due to coccidia or worms); and husbandry-related diseases such as ruminal acidosis. Across different villages 40–75% of farms had livestock died in the monitoring period. Another case series of diseases observed by the project staff is shown in Table 13, with more details provided in a full report upon request. Outbreaks were seen in different areas of Sindh and Punjab, including confirmed cases of FMD and PPR. Multiple households were affected in each case, with significant mortality and/or morbidity.

An important feature of both of these disease case series, many of notifiable transboundary diseases, is the complete absence of surveillance or response measures from local animal health services at any village site. This was the case despite staffed District Livestock Department offices at all locations. It suggests that such outbreaks are routine but that awareness amongst farmers and local animal health services of potential prevention or capacity to respond is low.

Table 13: Summary of disease case studies observed during project field operations

Date	Location	Number of HHs	%/n affected	Tentative diagnosis	Animal health service involvement	Comments
Dec. 2021	Rajanpur, Punjab	8	35-40% mortality	PPR§	Nil; no history of recent vaccination	Ciprofloxacin recommended as routine treatment, despite AMR concerns
Nov. 2020	Chakwal, Punjab	6	8 abortions	Unknown	Nil	
June 2021	Chakwal, Punjab	10	50% affected; 8 deaths	FMD*	Nil	Only 6/19 HHs had recently vaccinated animals Estimated cost: 600 R/head/d
Nov. 2021	Badin, Sindh	8	60-70% mortality	PPR*	No prior investigation; limited response after prompted by project	No prior history of vaccination, despite claims by livestock department office

§ unconfirmed

** serological confirmation by project staff*

Blood samples were collected from animals in a range of households in the Longitudinal Health Monitoring study in Bhurpur village, Punjab (see Section 7.2.4.2). Subsequent testing for PPR, FMD, CCPP and brucellosis showed that many animals had been exposed to PPR and FMD (CCPP and brucellosis results pending). About two thirds of animals were positive for PPR, with no difference between species (P = 0.20) or season of sampling (P = 0.69; Figure 14). Adults had nearly three times the odds of being positive than young animals (odds ratio 2.8 (95% CI 1.6–4.8), reflecting the likely ongoing exposure of household herds to the disease leading to increasing seroprevalence with age. A smaller proportion of animals were seropositive to FMD, although up to 20% of

sampled animals were positive to Serotype O (Figure 15). The presence of multiple strains of FMD suggests a very endemic disease state with ongoing virus circulation, rather than an acutely propagating outbreak from a single recent point source.

These results show that transboundary disease outbreaks are widespread. They likely have important impacts on village SR production, although more investigation is needed into the extent and nature of this, and that existing control and prevention efforts need substantial strengthening to address this important issue.

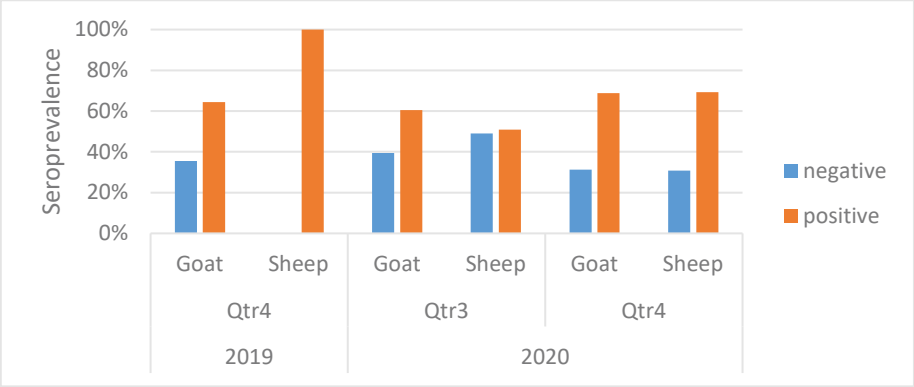

Figure 14: Prevalence of PPR in adult and young SRs in Bhurpur village, Punjab 2019–2020

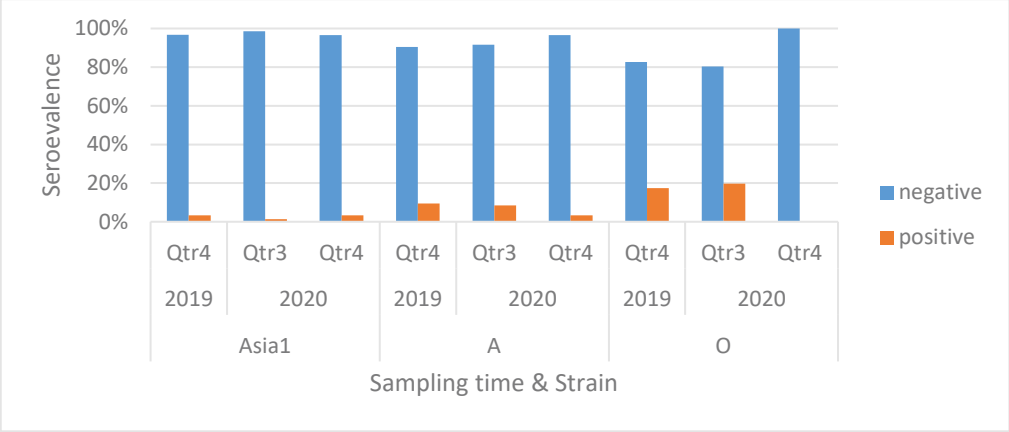

Figure 15: Prevalence of FMD serotypes Asia1, A and O in adult and young SRs in Bhurpur village, Punjab 2019–2020

7.2.4.2 Prevalence of anaemia in SRs

The Longitudinal Health Monitoring study also measured key generic animal health traits, including anaemia, serum protein, body condition and parasite status and disease syndromes in six villages across Punjab and Sindh. The study could not continue because of COVID-19 lockdowns but animals in one village, Bhurpur, were monitored throughout 2020. A key finding from Longitudinal Health Monitoring was that anaemia, measured both by packed cell volume (PCV) and FAMACHA (van Wyk and Bath 2002) examination of ocular mucous membrane colour, was very widespread throughout the year, particularly in adult goats (Table 14). In December 2020, when four villages were surveyed, 23–43% of adult goats had severe anaemia (FAMACHA ≥ 4), with at least the same proportion again categorised as marginal. Observations in Bhurpur throughout 2021 showed 32–54% of adult goats had severe anaemia. Fewer sheep were affected, with only 0–17% of adults with severe anaemia across the four village sites in December

Table 14: Proportion of adult goats and sheep with different FAMACHA scores at 4 villages and throughout the year at Bhurpur village

			FAMACHA category (score)		
Species	**Visit**	**Village**	**Normal (1-2)**	**Marginal (3)**	**Anaemic (4-5)**
Goat	Dec-20	Din Muhammad Kathio *	13%	55%	32%
		Rakh Mankera	4%	59%	37%
		Saddiq Jatt	25%	44%	31%
		Bhurpur	8%	33%	60%
	Jan-21	Bhurpur *	6%	54%	41%
	Feb-21	Bhurpur	5%	47%	48%
	Sep-21	Bhurpur	1%	45%	54%
	Nov-21	Bhurpur	3%	36%	62%
Sheep	Dec-20	Rakh Mankera	13%	64%	24%
		Saddiq Jatt	79%	18%	3%
		Bhurpur	50%	46%	4%
	Jan-21	Bhurpur	42%	47%	11%
	Feb-21	Bhurpur	31%	54%	15%
	Sep-21	Bhurpur	49%	45%	6%
	Nov-21	Bhurpur	25%	66%	9%

** Within species, between villages in December 2020* or *within Bhurpur across visits, * indicates statistically significant differences in frequencies (P ≤ 0.02)*

2020, and 4–11% affected throughout 2021 in Bhurpur. Young goats and sheep followed similar patterns to adults but there were fewer anaemic animals (data not shown).

Anaemia was a similar problem when it was measured in other experiments throughout the project, suggesting this is a widespread and potentially important problem. For example, on average across the trial in each village site 10–25% of young goats enrolled in the local creep feeds trial across six villages in 2021 were severely anaemic (FAMACHA ≥ 4; data not shown) with no statistically significant variation across the five measurement periods of the trial (P > 0.1). The greatest proportion of animals with severe anaemia was 43%, in Saddiq Jatt, Sindh at the start of the trial, and overall an average of 19% of SRs had severe anaemia.

Although FAMACHA is a semi-quantitative measure, the extent of these problems was verified in PCV measurements conducted alongside FAMACHA in the Longitudinal Health Monitoring study. PCV measurement showed similar patterns of proportions of anaemic animals.

There are several potential causes of the observed anaemia but we were unable to establish a definitive diagnosis because COVID-19 prevented timely, in-depth disease investigations in the villages by the project. Although longitudinal monitoring of faecal worm egg counts (WECs) at one village site suggested that gastrointestinal parasitism was a moderate problem on some occasions (Figure 16), it was not high enough to suggest *Haemonchus contortus* infection, a common cause of anaemia. No liver fluke eggs were detected either. This leaves ticks or tick-borne haemoparasite infections as possible important causes.

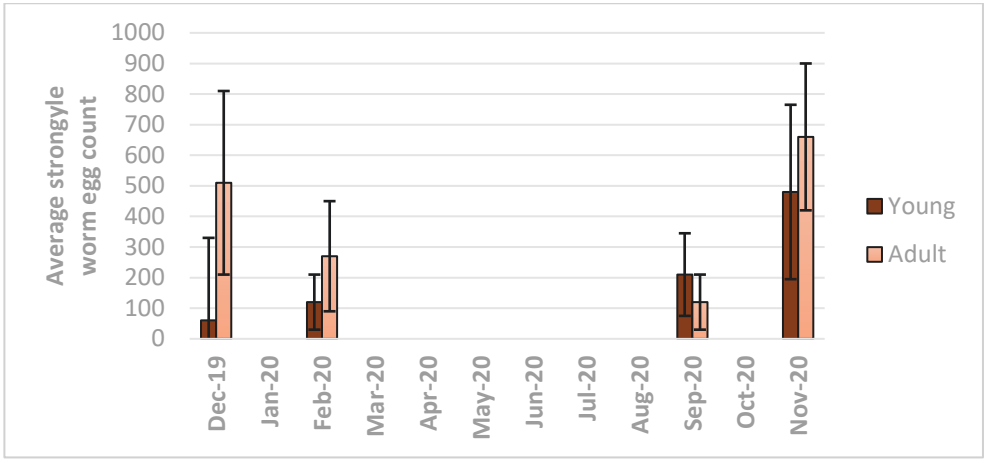

Figure 16: Seasonal variation in strongyle worm egg counts in Bhurpur village, Punjab

7.2.4.3 Tick infestation

Tick infestations were common throughout the Longitudinal Monitoring Study, with a majority of animals carrying mild to moderate burdens throughout the early rainy season at all monitored sites in 2021 (Figure 17). Although the level of infestation was unlikely to have been solely responsible for the degree of anaemia observed, ticks clearly contributed to the problem as shown in Figure 18 from the local creep feeds study. Goats and sheep with moderate to severe tick infestations had 2.0–2.3 times the odds of having severe anaemia (FAMACHA 4–5) than animals without ticks ($P < 0.01$). Controlling for the effects of household, a one-unit increase in tick severity corresponded to a 37% increase in odds of having severe anaemia (95% CI for odds ratio 1.2–1.6). Anaemia was probably caused from the direct effects of tick infestation plus increased transmission of haemoparasites, but this needs more investigation so that appropriate prevention and treatment recommendations can be developed to manage this widespread problem.

A key recommendation from this series of findings is that veterinary services (government, NGO) should more proactively document and investigate anaemia in SRs in Pakistan. This is a straightforward procedure involving FAMACHA assessment (which farmers can do), worm egg count (could be performed at local District Veterinary Offices) and

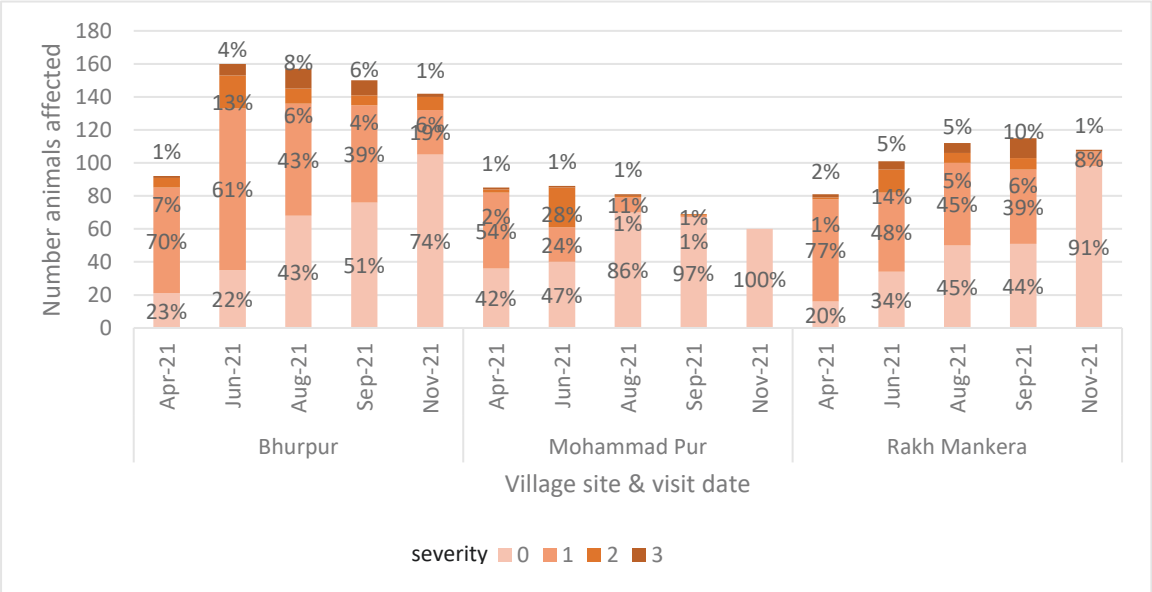

Figure 17: Severity of tick infestations (0–3: *none–severe*) in young animals in the Local Creep Feeds Trial in Punjab in 2021

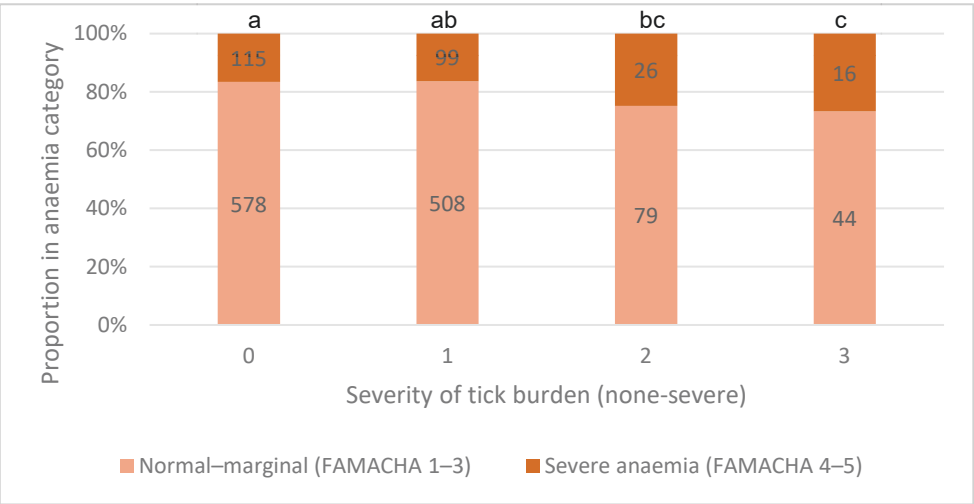

Figure 18: Proportion of animals with different tick burdens with severe anaemia (bar labels = number of observations; bars with different letter labels differ at P < 0.05)

examination for ticks. With existing knowledge, this approach would at least rule out the common problem of worms as the cause of anaemia. Trial treatments of identified tick infestations could be undertaken, or blood samples collected for further detection of haemoparasites and evaluation of their impact.

This simple investigative approach is also strongly recommended because the observed signs are consistent with Crimean Congo Haemorrhagic Fever, a potentially fatal zoonosis that is present in Pakistan (WOAH 2022).

7.2.4.4 Pre-slaughter factors affecting carcass and meat quality

An observational study of goats in lairage at a major Lahore abattoir showed that on-farm health issues permeate right through to animals being sold and slaughtered for human consumption. Three quarters of animals slaughtered were in thin body condition, a surprising finding amongst animals sold in apparently satisfactory condition for slaughter (Figure 19). Significant proportions of animals had severe faecal soiling (16%) or nasal discharge (40%), representing potentially important food safety threats. These issues could also arise from poor conditions on-farm before sale or during transport, or forced selling due to illness, which would likely reduce sale prices received by farmers, and affect animal welfare or suitability for sale and consumption.

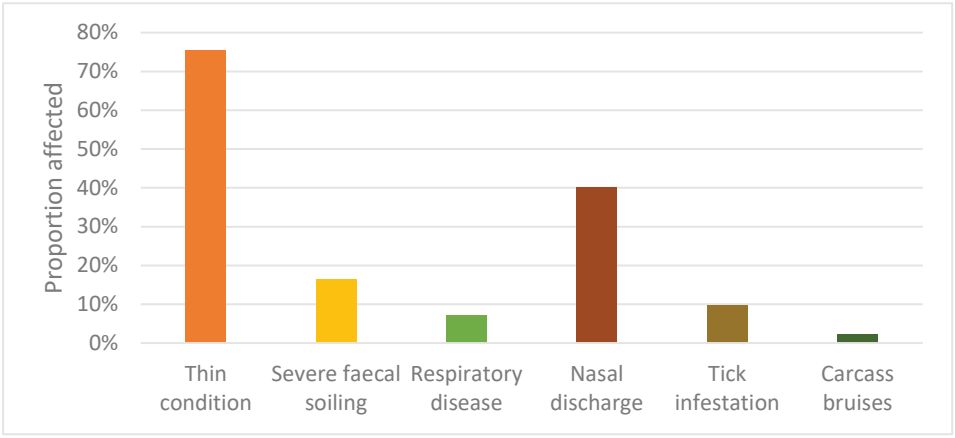

Figure 19: Prevalence of health conditions in goats (n = 300) in abattoir lairage

7.3 Zoonotic disease

Relatively little is known about the risk of zoonoses associated with SR farming in Pakistan, and we conducted a Knowledge, Attitudes and Practices (KAP) of zoonotic diseases amongst women and men SR farmers from two villages in Punjab and Sindh using focus group discussions and a structured questionnaire.

Female and male farmers' knowledge of SR disease and zoonotic implications differed between provinces, with less awareness of zoonoses in Sindh than Punjab ($P < 0.01$). Women listed more diseases (both animal-specific and zoonotic) than men as affecting their SRs in Punjab (18 for women vs. 10 for men), but fewer in Sindh (21 vs. 33). There was almost no correlation between the disease nominations and importance rankings of women and men. Nonetheless, a similar proportion of both lists were zoonoses. When farmers were asked to list the three most important diseases affecting a household's SRs, a greater proportion of those listed by women were zoonoses compared to men in both Punjab (24/30 vs. 9/30, $P<0.01$) and Sindh (13/21 vs. 11/33, $P=0.04$).

Typically, women and men included the zoonoses anthrax, listeriosis, scabby mouth, brucellosis and 'tick bites' in their lists of conditions affecting SRs. Importantly, interviewees only identified 'tick bites' as zoonotic, with all other diseases described as affecting animals only. Q Fever (coxiellosis) was never mentioned as a condition affecting participants' animals. In several interviews, women farmers described suffering from a condition that was likely human orf (ovine parapoxvirus) infection, but did not associate it with scabby mouth infections in their SRs.

Attitudes and practices relating to potentially risky actions around zoonoses are shown in Figure 20. Overall, men were more likely to be involved in risky practices that can pose a threat to health (odds ratio men compared to women: 1.9 (95% CI 0.90–3.9; $P < 0.10$). The most common risky practices included slaughtering or selling sick animals that were dying, and direct contact with aborted animals. Although listeriosis was nominated as a disease affecting interviewees' animals, 55% of households consumed raw milk and/or milk products, with 46% of farmers considering there was low/no risk of disease transmission through raw milk. Householders considered unpasteurised milk to be "more nutritious and healthy", especially for children.

This work showed that, while SR farmers have a good awareness of diseases that potentially affect their animals, there is poor knowledge of how some of these conditions can also affect humans. These insights may be overlooked in solely quantitative survey approaches, especially those that do not address gender. Historically, extension and

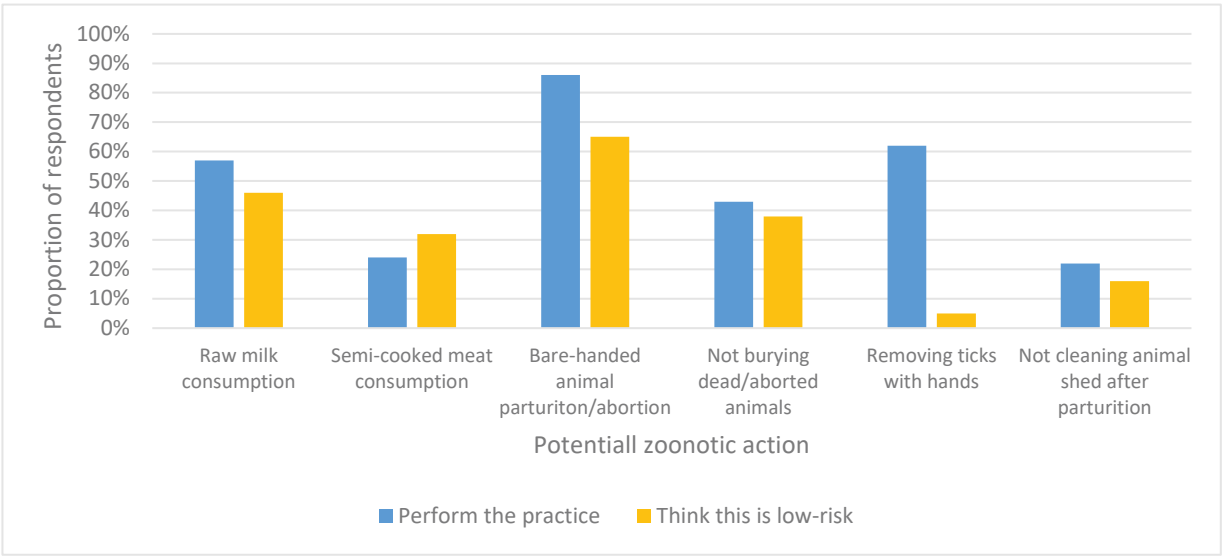

Figure 20: SR farmer practices and attitudes to potentially zoonotic actions

engagement programs for animal health or zoonoses have not considered women's and men's differing needs and access to information about livestock keeping. Our results show that women, who typically have difficulty accessing farming knowledge due to limited social mobility, have important SR farming knowledge to offer, but that both women's and men's knowledge of zoonotic disease risks in the Pakistan SR sector is universally poor. Disease awareness and control programs need to incorporate this information to reduce zoonosis risk more effectively and equitably for people raising SRs.

7.4 Strategies to improve survival and growth of young animals

The observational studies described in the previous sections identified several important issues: high wastage of young animals through mortality and failure to thrive; a perception by farmers that nutritional resources limit their SR production; a nonetheless wide availability of potential feeds that could be offered to SRs throughout Punjab and Sindh, and; a beneficial association between feeding high-quality feeds and survival. Together, they provide a compelling case for using targeted supplementation, or 'creep' feeding, to profitably improve growth and survival of young animals. The efficacy of creep feeding has a strong biological foundation and has been shown to improve growth and survival in different settings (Hocking Edwards *et al.* 2008; Campbell *et al.* 2009, 2014), including with smallholders (Cho *et al.* 2017; Glanville *et al.* 2017). Consequently, we conducted two field trials to evaluate and promote the use of creep feeding by smallholder farmers.

7.4.1 Pilot Creep Feeding Trial

The Pilot Creep Feed Trial tested a commercial pelleted feed, 'Wanda', in 36 households from four villages in Punjab and Sindh. All goats and sheep less than 6 months old from each household were enrolled in the trial. Intervention (creep feeding) households were from one village and control households from a similar, neighbouring village. This study design was used to overcome the project team's concern that householders would not readily accept randomisation to the control group, although this confounded the design. Farmers offering creep feed were encouraged to provide trial animals with free access to water and time spent untethered.

Creep feeding had a variable effect. In Sindh, there was significantly lower mortality in the village using creep feeding than the control village (9% vs. 29%, respectively; $P = 0.005$). In Punjab, greater mortality occurred in the creep feeding village than the control (29% vs. 14%, respectively; $P < 0.001$). This was likely associated with an outbreak of coccidiosis in many households in the intervention village, where 12 of the 35 (34%) deaths across creep and control animals were due to diarrhoea. There were no creep feeding-related differences in the weights of goats or sheep in either province.

At the completion of the study, we interviewed 98 people: 73 who directly participated in the study (Intervention: 18 F, 18 M; Control: 17 F, 20 M) and another 25 (16 F, 9 M) who were village neighbours or relatives of the Intervention households but did not directly participate in the trial ('Spillovers'). Interviewees from the intervention sites reported an average of 2.3 benefits from being involved in the trial, compared to 1.3 benefits from Control households in the neighbouring village. Women and men experienced benefits of creep feeding differently (Table 15) and there were differences in the proportion of participants who said they would try the intervention themselves in the future. Notably, 63% of women participants in Sindh, where social mobility often limits women's' access to capacity building, reported learning something through participating in the field trial. Only 22% of Punjabi women reported learning something from participating in the trial.

Unsurprisingly, feed-related benefits were most common in Intervention households because the trial provided 6 months' supplement for all the households' kids and lambs. Most Intervention households reported either receiving a better price or perceiving they had the opportunity to receive a better price for animals that were sold during or after the

trial, in both Sindh and Punjab. Control households, who did not receive feed until the end of the trial, still reported a benefit from regularly weighing of their animals.

In the Spillover interviews, 56% of interviewees had learnt about the trial and 80% observed improved weight or health in the creep fed animals. There was no difference in the proportions of women and men who had learnt about creep feeding or observed its results in their neighbours'/relatives' households. Most Spillover interviewees were interested in trialling creep feeding themselves, but this was less so in Punjabi women than the other interviewees.

Creep feeding had a variable effect on labour time of householders, causing modest increases or decreases, or no change (Table 15). In some cases, creep feeding led to substantial increases in time required to manage SRs. This particularly occurred for providing water, because maintaining an *ad lib* offering meant fetching water more often during the day. Improved water availability is associated with better creep feeding results (Glanville *et al.* 2017) but the burden this can place on farmers, especially women, must be remembered and strategies such as providing pumps or larger storage vessels should be considered to make the overall intervention more achievable and sustainable.

Twelve of the 14 respondents that would not creep feed again said it was due to cost of the commercial feed. However, anecdotally in later years of the project, households reported purchasing feed for creep feeding when spare money was available. Overall, this pilot trial showed that creep feeding has potential to improve survival but is not a 'cure-all' solution. Creep feeding did not replace the need for health monitoring and prompt response to disease. This emphasises the need for more effective health services for SR farmers described in Section 7.2.4.1. It also showed that household finances and labour must be considered in the design of the intervention. There will be poor acceptance if unaffordable feeds are recommended, and additional livestock water

Table 15: Reported benefits and labour changes (range/proportion) involved with creep feeding, including willingness to creep feed in the future

Topic	Specific responses	Female		Male	
		Punjab	Sindh	Punjab	Sindh
Survey participants		9	9	9	9
Total benefits		16	23	26	18
Average benefits/ participant		1.8	2.6	2.9	2.0
Reported benefits from being involved in the trial	Health	2 (22%)	2 (22%)	3 (33%)	1 (11%)
	Growth	1 (11%)	1 (11%)	2 (22%)	2 (22%)
	Feed	7 (78%)	9 (100%)	8 (89%)	6 (67%)
	Weight gain	2 (22%)	4 (44%)	7 (78%)	3 (33%)
	Other	4 (44%)	7 (78%)	6 (67%)	6 (67%)
Labour changes associated with implementing creep activities	Change to routine	5 (56%)	7 (78%)	4 (44%)	3 (33%)
	Cleaning ease	9 (100%)	7 (78%)	9 (100%)	9 (100%)
	Cleaning time (min)	6 (-30–90)	12 (-30–30)	9 (0–30)	8 (0–30)
	Providing feed ease	6 (67%)	4 (44%)	5 (56%)	2 (22%)
	Feeding time (min)	7 (-25–60)	14 (-20–30)	14 (5–30)	18 (0–60)
	Free water access	7 (78%)	5 (56%)	7 (78%)	6 (67%)
	Time providing water (min)	53.3 (0–240)	14.4 (-30–30)	6 (0–30)	5 (-30–30)
Potential value of creep fed animals and weight data	Received better price	8 (89%)	2 (22%)	6 (67%)	5 (56%)
	Weight data useful	9 (100%)	8 (89%)	7 (78%)	8 (89%)
Involved in creep in the future	No	4 (44%)	5 (56%)	3 (33%)	2 (22%)
	Yes	5 (56%)	4 (44%)	6 (67%)	7 (78%)

infrastructure may be needed to make creep feeding possible where water supply is restricted.

7.4.2 Local Creep Feeds Trial

A second, larger creep feeding trial was conducted in 2020–21 with 121 households from six villages in Punjab and Sindh. Workshops were held before the trial to discuss the available feed resources in each village to select high-quality feed rations for creep feeding. The feeds selected are shown in Table 16. These were considered by farmers as readily available in the village and used in livestock feeding (although infrequently for young SRs prior to the trial). In contrast to the Pilot Creep Feeding Trial, households within the same village were randomised to creep feeding or control (management as usual) groups. The trial duration varied slightly between villages but ran for an average of about 6.5 months.

Across all villages and households, on average creep feeding produced an extra 1.3 kg (95% CI 0.03–2.4, $P < 0.05$) weight gain (average unadjusted weights across the trial are shown in Figure 21) and 1.5% extra survival compared to animals in control households (least squares means). The differences in weight gain and survival between creep feeding and controls varied between the six trial villages. Growth rates in creep were similar or better than controls in four villages, and survival was similar or better in three of the six sites (Table 17), although relatively low numbers of observations limited the statistical significance of these results.

Approximately 40 kg per head of feed was offered per head over this time, with the total feed cost ranging from about PKR1,300–2,300/head (≈ AUD9.30–16.40 at 2021 prices). Overall, the value of this extra weight gain and survival was greater than the cost of feeding. Thus, on average creep feeding was cost-effective and delivered an extra net ~5-10% on the animal value. However, some farmers reported an increase of many thousands of rupees for animals that had been creep fed.

Many control households began using creep feeding with their own resources after several months as they observed their neighbours' creep-fed animals, so this advantage from creep feeding is likely conservative compared to typical management of SRs in a typical smallholder village setting.

Creep feeding had important impacts on labour performed by different members of households. This appeared to be principally associated with the use of the creep barrier, which reduced the need to supervise the herd/flock to make sure adults did not eat the creep feed. The majority (63%) of women farmers from intervention households reported at the end of the trial that creep feeding reduced their labour requirement for managing SRs (Figure 22, left). Men reported a similar benefit, although more respondents said their labour requirement was unchanged by creep feeding. Importantly, in households

Table 16: Feeds used at each village site in the Local Creep Feeds Trial

Province	District	Village	'High quality' feed (33%)	'Low quality' feed (67%)
Punjab	Bhakkar	Rakh Mankera	Chickpea grain	Chickpea straw
	Chakwal	Bhurpur	Cottonseed cake (CSC)	Peanut straw
	Rajanpur	Muhammad Pur	Cottonseed cake	Whole wheat grain*
Sindh	Badin	Saddiq Jatt	Wheat bran	Wheat straw
	Tando Allahyar	Din Muhammad Kathio (DMK)	Wheat bran	Wheat straw
	Tharparkar	Lunihar	Cottonseed cake / Wheat grain	Rice polish

** Even though readily available and fed to older animals, farmers were reluctant to feed wheat straw to young animals believing it causes gut impaction. Feeding whole wheat (ground) plus CSC to young animals is common but presumably has labour costs. CSC plus whole wheat was used as a practical, acceptable compromise.*

where children helped manage SRs, all girls had reduced (87%) or similar labour requirements (Figure 22, right). Boys experienced similar benefits, although labour increased for two (7%).

Participating in the creep feeding trial appeared to impart important increased confidence and knowledge about overall management of SRs, based on comparison of participants' baseline and endline knowledge/attitude/practice responses from were compared. Most farmers perceived a reduction in difficulties related to animal morbidity and mortality by the end of the trial. Of 145 interviewed farmers, 58% rated sickness and death of young

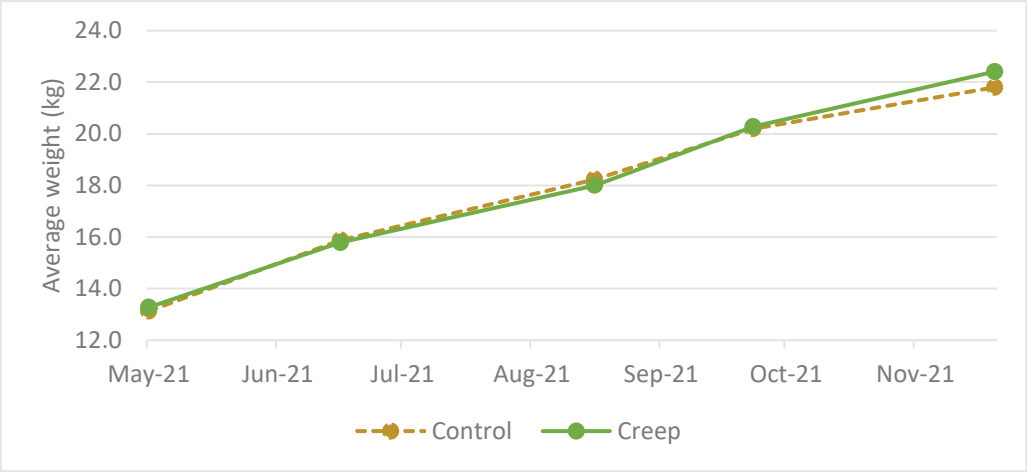

Figure 21: Average weights across all village sites of creep- and traditionally-fed SRs in the Local Creep Feeds Trial

Table 17: Comparison of weight gain and mortality (95% CI) between creep and control groups in trial villages

	Village	Average growth rate (kg/month)		Mortality rates (deaths/100 head/6 months)		Mortality rate ratio*
		Creep	Control	Creep	Control	
Punjab	Bhurpur	1.33	1.10	10.6 (5.3–21.1)	24 (15.1–38.1)	0.40 (0.17–0.95)
	Mohammad Pur	1.90	1.49	16.7 (7.5–37.1)	2.4 (0.3–17.3)	6.8 (0.82–57)
	Rakh Mankera	1.31	1.65	6.1 (2.3–16.4)	15.3 (7.7–30.7)	0.36 (0.11–1.2)
Sindh	DMK	1.05	1.02	13.7 (7.4–25.5)	4.9 (1.6–15.1)	2.8 (0.78–10)
	Lunihar	1.19	1.30	2.4 (0.6–9.4)	1.5 (0.2–10.7)	1.36 (0.12–15)
	Saddiq Jatt	1.37	1.06	31.8 (20–50.5)	24.6 (12.3–49.3)	0.60 (0.2–1.8)

** Creep vs control; numbers < 1 show better survival in creep than control group*

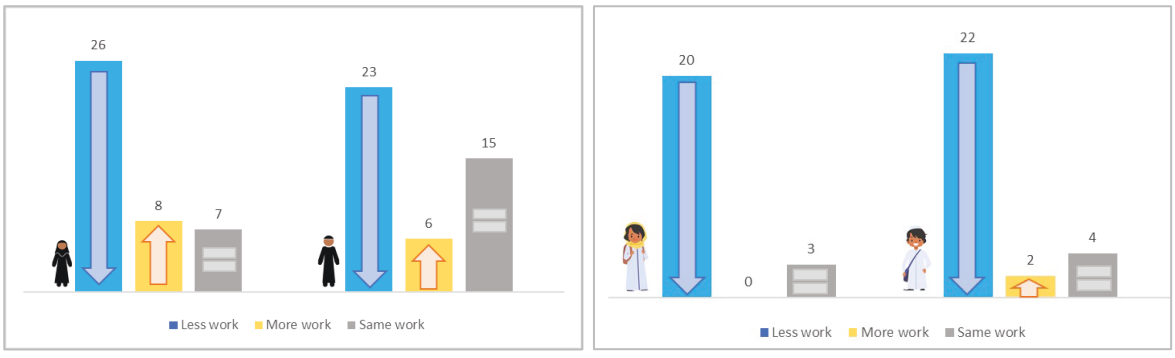

Figure 22: Impact of creep feeding on amount of labour reported for adult women and men (left) and girls and boys (right)

animals as being less of a problem on their farm at endline compared to baseline (Figure 23). About one third (37%) reported no difference – however over two thirds of these had already rated illness and death as a minor problem at baseline. This means the strong majority of farmers either perceived an improvement in animal health and survival, or a continuation of already good health and survival, across the trial. Perceived improvement of animal health was similar across both treatment and control farms, suggesting either that external environmental factors impacted the improvement, or that contact with the project, and the animal management and health training and advice provided to all farmers throughout the trial contributed to the perceived improvement.

Most participants already believed supplementary feeding of young SRs was important at baseline, and continued to hold this belief. However, by endline more participants believed it was possible to improve the survival of young SRs. At baseline, about two thirds thought it was possible, and about one quarter were not sure. By endline, almost 90% believed it was possible (Figure 24). The increase was partially driven by women, almost half of whom were "unsure" at baseline about being able to improve survival. The reduction in the "unsure" group may reflect the knowledge-sharing approach taken in both treatment and control farms, and a corresponding gain in knowledge and confidence, particularly for female farmers. When asked whether younger or older SRs are easier to care for, most participants felt older SRs were easier. From baseline to endline, most

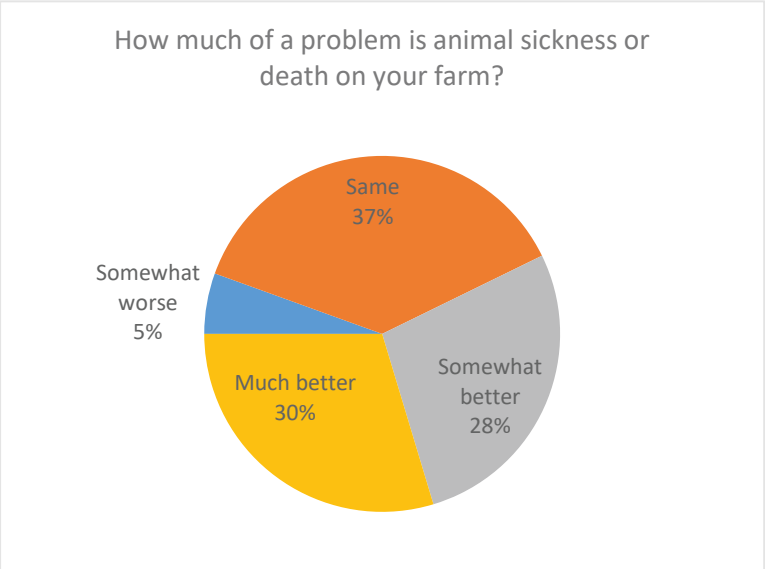

Figure 23: Change in trial participants' perceptions of ease managing SR health between start and end of Local Creep Feeds Trial

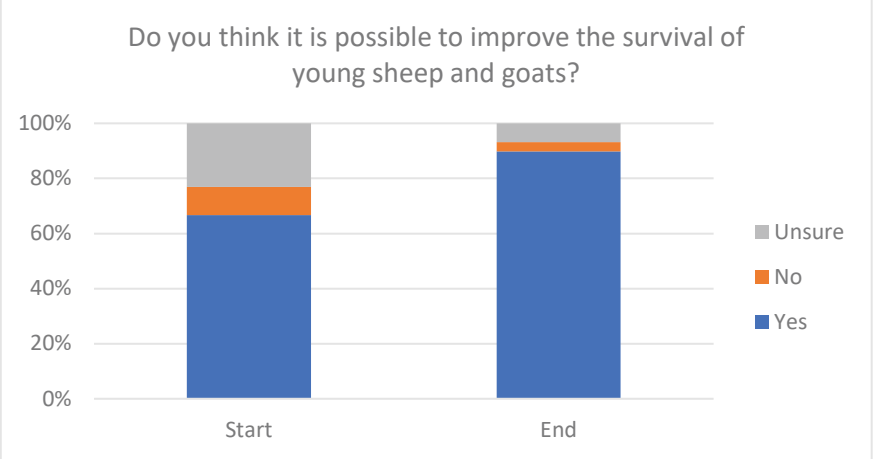

Figure 24: Proportions of farmers with different opinions about ability to improve SR survival at start and end of Local Creep Feeds Trial

maintained the same response, however there was some change towards rating younger SRs as easier to care for, particularly among the treatment group. This corresponds with the feedback from farmers that, for most, the creep barrier reduced their workload in caring for young sheep and goats. Overall, there was a strong intention to continue to use creep feeding, including in control households (Figure 25). This was greater than following the Pilot Creep Feeding Trial, suggesting that the use of local feeds made the intervention more relevant and usable for smallholders.

The results from this trial provide important insight into the potential utility of creep feeding and, more importantly, how creep feeding should be introduced to smallholder households. Although the increases in growth and survival created from creep feeding were relatively small on average, farmers appeared to perceive that it offered a range of benefits that were not always immediately obvious or anticipated by the research team. This is supported by the uptake of the intervention by many control households during the trial, despite receiving no feed from the project at that time. Implementing the intervention in a participatory manner seemed to increase farmer confidence, gave them greater insight into the practicalities of creep feeding, and allowed farmers and project staff to address issues as they emerged. For example, one village experienced difficulties using the ration they initially selected, and the team could help them use an alternative and continue the intervention. This approach was vital to keep farmers in the trial and contributed to the strong support for continuing the intervention themselves after the end of the trial.

Nonetheless, the variability in animal response to creep feeding across households and villages is a reminder that creep feeding is not a panacea for all problems in SR production. It can be disrupted by disease outbreaks, emphasising the need for close technical support as the practice is being introduced to farmers. Furthermore, its sustainability depends on careful choice of local feeds, and feeding should be started using standard practices such as a 2-week introduction phase.

The issue of cost-effectiveness of creep feeding identified with the commercial supplement in the Pilot Creep Feeding Trial was also illustrated in a creep feeding demonstration activity conducted at the Sindh Livestock Department's Kamori goat research farm at Dadu. Animals were largely offered a range of locally-grown feeds, with the commercial feed 'Wanda' offered behind a creep barrier in one pen and crushed wheat offered in the non-creep pen (Figure 26). Whilst the commercial feed only comprised 7% of the diet offered, it made up 78% of the total cost of the ration. Creep-fed animals gained on average 14.2 kg/head compared to routine kids' gain of 12.7 kg/head. Creep-fed kids consumed 12% more feed than kids under routine feeding, which cost

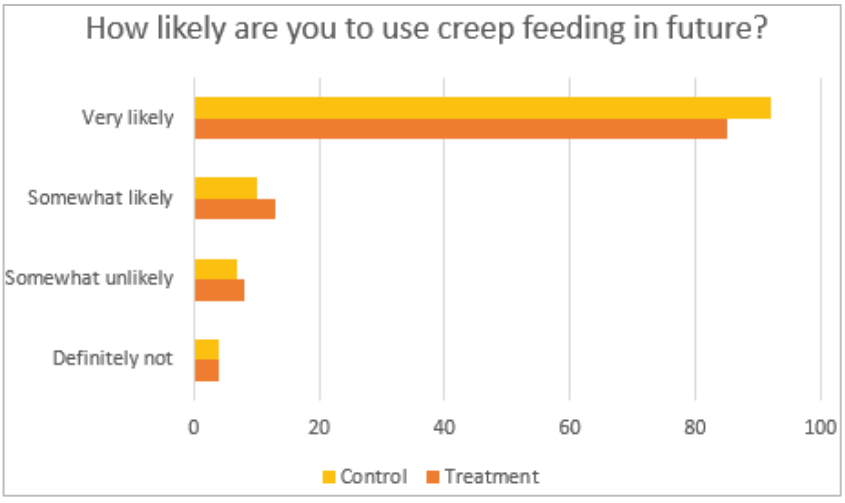

Figure 25: Proportion of Local Creep Feeds Trial participants intending to continue using creep feeding in the future

138% more than the routine ration. At 2022 prices at Eid (when livestock prices are highest), the additional 1.5 kg weight gain was worth an extra 1600 PKR/head, at a cost of extra feed of 1170 PKR/head, producing a net benefit of 430 PKR/head and a return on the extra feed investment of 37%.

This demonstration shows that, although creep feeding is biologically successful, its profitability is very sensitive to cost of the feed. Feeds must be selected carefully to ensure the benefit:cost of creep feeding is optimised; choosing cheaper local feeds, providing quality can be guaranteed and farmers are confident to use them, will usually be preferable to more expensive commercial rations, especially when weight gains are relatively modest as observed in our studies.

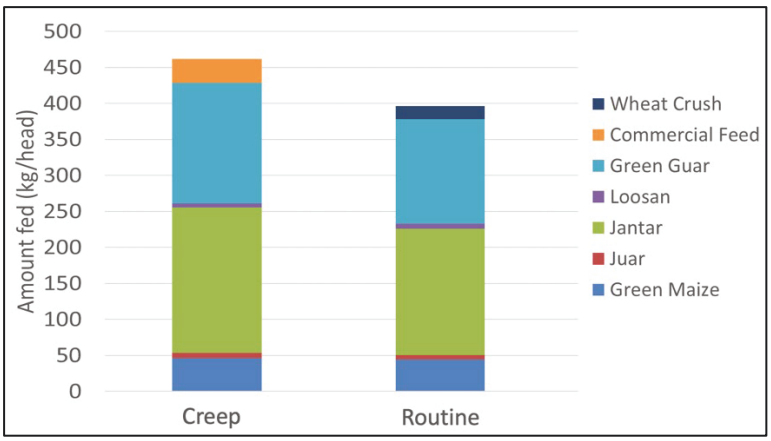

Figure 26 : Total quantity of feeds offered to creep- and routine-fed animals at Dadu research farm

7.5 Potential for improving smallholder livelihoods through engagement with value chains

An important aspect of the project's impact pathway was linking improved on-farm production with the rest of the SR value chain. Objectives 2[6] and 3[7] included descriptive studies to understand the nature of some of these opportunities, plus some intervention trials to test new approaches. The results of this work are described in this section, and should be read along with the more detailed description of the nature and scale of the impact of this work in Section 8 and particularly Section 8.3 (*Community impacts – now and in 5 years*). Close, personal engagement with sellers and buyers throughout the early stages of the value chain was needed for these activities, and they were particularly disrupted by lockdowns and travel restrictions due to COVID-19. As a result, less detailed results were produced for these themes than other parts of the project.

7.5.1 Attaining SR market specifications and opportunities

The SRA that preceded this project described several distinct SR value chains in Pakistan: a traditional wet market, an emerging domestic supermarket and chilled meat trade, carcass export and a religious value chain centred around the holy festivals of Eid al-Adha and Eid al-Fitr. The Religious Value Chain was investigated in a Consumer

[6] *Develop and test strategies small ruminant farming families can use to access market opportunities and attain market specifications*

[7] *Identify and trial opportunities for women and their families to derive more benefits from small ruminant production and marketing*

Preference survey involving 53 potential SR buyers at three livestock markets (mandis) just prior to Eid al-Adha in 2019. All customers were male and over half (56%) were aiming to buy only one animal. Over half of buyers were looking for an animal 21–30 kg carcass weight, with 96% having a specific carcass weight in mind. Carcass weights were estimated on visual assessment only. Preferences were for two-toothed (one year-old) and phenotypically "attractive white" or single-coloured animals; 43% of customers had a specific breed in mind, although the actual breed varied between buyers. There was a wide variation in the price buyers were intending to pay, from 15,000–60,000 PKR/head, but most (62%) were looking to pay between 20,000–30,000 PKR, which was about 2.5 times the typical prices of animals in the non-religious traditional domestic value chain at the time. Forty-five percent of buyers had difficulty finding desired animals.

On the supply side, the Smallholder SR Marketing Practices survey across project villages at Eid in 2020 showed that 81% of farmers undertook specific actions to prepare SRs for sale at Eid, including providing extra concentrated feed, administering specific medications/treatments, grooming, or providing special housing. The average preparation costs were 8900 PKR/head which, if these values are comparable to the buyer results from the preceding year, represent 30–45% of the gross price typically received at sale. The characteristics that farmers (sellers) and buyers thought were important for price were not well correlated (Table 18). Even the most important characteristics were listed by less than half the farmers surveyed as things they thought were important for the value of the animal.

Table 18: Proportion of farmers (n = 55) nominating characteristics as important for a good SR price at Eid, and relative importance placed by buyers on these characteristics

Selling characteristic	Proportion	Identified by buyers
Appearance, colour	47%	✓✓
Weight	40%	✓✓✓
Breed	29%	✓✓
Health	25%	
Sex	16%	
BCS	16%	
Age	9%	✓✓✓
Size	4%	
Other	5%	
Don't Know	11%	

Overall, 56% of farmers sold more than half their SRs at Eid al-Adha but 24% of surveyed households did not trade any animals at Eid. There was no correlation between the proportion of a household's annual income derived from SRs (compared to other livelihood activities) and the proportion of the year's SR sales that occurred at Eid. This suggests that farmers do not see some overall compelling reason to trade animals at Eid compared to other times of the year, since they would likely sell at this time and derive greater income if they thought this would happen. Alternatively, the messages and outcomes of selling at Eid are not reaching farmers and producing actual benefits. An ongoing, anecdotal recommendation from government, academia and other sector 'leadership' was that farmers would maximise their SR income by selling animals at Eid. Our results show that this message is not at all straightforward. The economics of targeting Eid sales need further research, since preparation costs appear to comprise a large proportion of sale price and could quickly erode profitability. Additionally, farmers do not appear to clearly know what characteristics buyers are looking for, so investments in animals and their preparation could be misplaced.

The abattoir study (see Section 7.2.4.4), which assessed animals sold into the traditional and new domestic value chains, showed that farmers often do not sell animals that meet market expectations or the required standards for food safety. Three quarters of animals slaughtered were in thin body condition, a surprising finding amongst animals sold in apparently satisfactory condition for slaughter. Significant proportions of animals had severe faecal soiling (16%), representing a potentially important food safety threat. These characteristics may reflect the idea that farmers sell SRs at relatively short notice when a household needs money, instead of purposefully preparing animals over a set period for sale. However, the idea of 'when-needed' selling and suitability for sale are not mutually exclusive. If farmers were provided with better capacity to fatten and prepare their animals to be *closer* to a suitable condition for sale throughout the year, it would help address these quality of supply issues, and deliver benefits to selling farmers, processors and consumers alike.

These ideas are reinforced by the findings of the 2021 SR Marketing Practices at Eid survey (see Section 7.2.1). Farmers indicated that improved access to traders, transport, feeds and knowledge about feeding would all help make trading SRs at Eid or other times more successful. This broad desire suggests that filling these service gaps, along with farmer capacity building, are needed to support the ability of farmers to sell their SRs successfully. A case study of a farmer using targeted feeding to meet market specifications more successfully occurred at one of the project research sites, Rakh Mankera in Punjab. There, one farmer used creep feeding with a commercial pellet to improve growth and fattening of young animals. This reduced mortality and provided him with the confidence to increase the number of animals under management from 4 head to 400 in less than a year.

In addition to the issues discussed above, multiple gender barriers to women's participation in markets and value chain activities were observed, against the backdrop of overall systemic inequity in access and ownership of resources and land. Travel to the location of activities or resources is not permitted for many women, and there are some cultural barriers to mixing even with unknown women from other areas, which limits access to centralised services and resources. Most village-level extension and animal health workers are male, and cultural regulations preclude women from having contact with them, despite women's demonstrated role in caring for young (and other) SRs and their greater risk of exposure to zoonotic disease, as discussed in earlier sections. The livestock markets are also a highly male-dominated setting, in which women are largely unable to participate; some women were however able to participate in occasional women-only markets held by local organisations. The active participation of women in women's-only training and focus groups on SR management organised in accessible settings, their willingness to consult with female project team members, as well as their direct requests for more training, indicated their appetite for greater engagement and opportunity.

7.5.2 Strategies for better participation of men and women in small ruminant value chains

Farmers were given access to livestock weighing scales in 2021 to test if they helped facilitate SR trading at Eid. In three of four villages, farmers underestimated the real weight of their animals by an average of 6.7 kg, or 14% of actual liveweight. In the fourth village, farmers overestimated their animals' weight by 10.2 kg or 37% (sample of 6 animals). On average, farmers revised their estimate of the value of the animal upward by 13% after they weighed it. However, for the 69% of farmers who revised their estimated price upwards after their animal was weighed, the median (upward) revision was 26%, suggesting that without accurate weight data most farmers under-estimate the price of their animals by a significant amount.

Nearly two thirds of farmers (64%) reported that using scales greatly improved the success of selling their animals (Figure 27). Three quarters (8 of 11) of farmers said the benefit of

using scales was that it fetched them a better price, with the others saying it helped with their ability to negotiate with traders or decide whether to sell their animals or not. In the Pilot Creep Feeding trial, 81% of participants surveyed at the end of the trial reported that knowing the weight of their animals by participation in the trial benefited them. This was chiefly associated with selling animals because weighing meant more information was available for negotiating with the buyer.

Even just providing farmers with the ability to objectively assess their animals' condition using body condition scoring (BCS) has potential to improve management and trading, with farmers trained in body condition scoring throughout the project rating the usefulness of the skill 4.9 out of 6 (6 = *extremely useful*). Women overall considered BCS training slightly more useful than men.

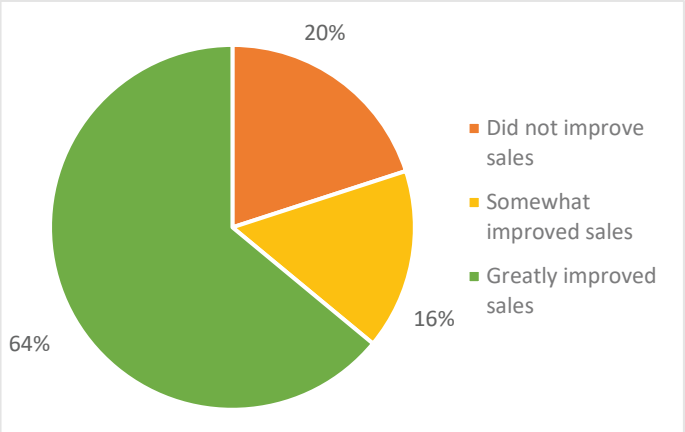

Figure 27: Effect of farmers using weigh scales to sell small ruminants at Eid

7.6 Opportunities for women and their families to derive more benefits from small ruminant production and marketing

Opportunities for the wider farming family, especially women and children, have been identified and described in several areas earlier in this section. Gender was mainstreamed through the project, and we describe many of the results of providing opportunities to women in the Impact section (Section 8) of this report.

Women have been shown to be particularly disadvantaged by the general lack of access to services that occurs in the SR sector. They often stated in our end-of-activity surveys that they wanted more training on key aspects of SR farming. Women appeared to prefer training on basic SR management, rather than more specialist topics. For example, women were twice as likely as men to want training on General SR Management, whereas they were similar to men in their statement of needs for other training topics (Figure 11, page 39). This may reflect their historic lack of access to training and, thus, requirements for more generalist training in the first instance.

The project provides case examples of women taking advantage of training when it was offered to them. Between 11% and 58% of participants in the village discussion groups outlining the Local Creep Feeds Trials were women acting as the sole representative of their household, unaccompanied by a male household member. Similarly, across the six Local Creep Feeds Trial village sites, similar numbers of women and men attended post-trial training and feedback workshops. These workshops were held separately and run by same-gender facilitators. Women specifically identified this as important for encouraging their attendance and participation.

Opportunities for increasing women's participation and benefits in SR farming were increased when information was delivered in an accessible form and location. The project used several iterations of disease information sheets to create material accessible to low-literacy users, who are often women. The first pictorial version was tested with women farmers and found to be unclear, so a new version was created using their feedback to clarify the key messages and delivery (Figure 28). Similarly, women farmers noted that the in-village, participatory research and training was valuable. A woman farmer in Sindh said, "*I appreciated the efforts of your team that provide us the best technique **at our doorstep** as we don't have idea of rearing kids by creep feeding… I usually sold my kids in 10,000 [PKR] before this technique but now I sold my kids 25,000 [PKR].*"

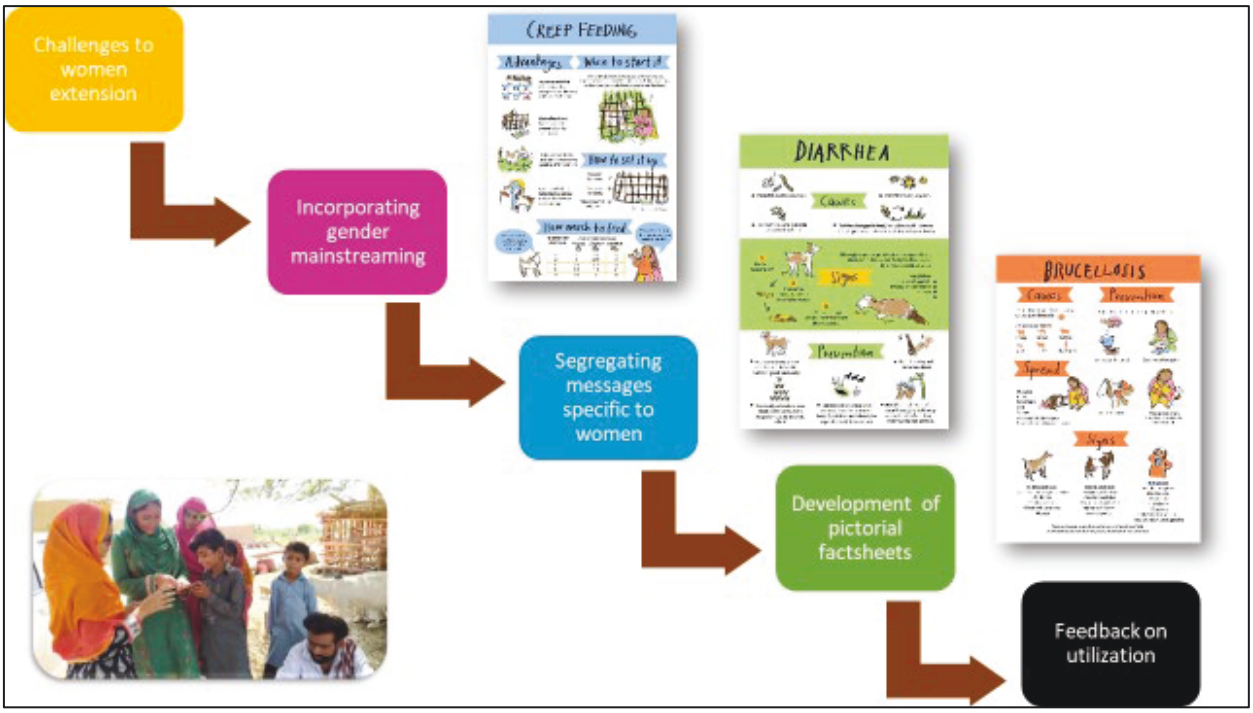

Figure 28 Development process for pictorial fact sheets intended for women

As noted in Section 7.1.2, women play specific, important roles in SR management. Our results show that strategies that can introduce labour savings can preferentially benefit women. For example, creep feeding significantly reduced the labour burden for women (and children) caring for SRs at home (see Section 7.4.2 and Figure 22). Future interventions to improve SR production should consider how they can be structured to account for these issues, and should measure gender-focussed outcomes such as labour, and changes in knowledge and confidence.

7.7 Summary of key results

The project has made a wide range of findings about the current state of smallholder SR farming in Punjab and Sindh, and effective ways to change smallholder production and marketing. The key findings from this work are:

1. Women play significant roles in SR farming, especially care of young SRs, in a very large majority of households, yet frequently have little access to knowledge and resources for SR farming
2. Both women and men readily engage in training and other activities to strengthen success of SR farming when these are provided in accessible forms, including information for low-literacy users and gender-appropriate face-to-face training

3. Local feed resources are effective for feeding SRs but farmers may lack the knowledge, confidence or resources to use them effectively for the stock classes on their farms that will benefit most from them
4. Currently on SR farms, feeding leguminous feeds reduces mortality in SRs, and use of these feeds where they are available should be promoted widely
5. Creep feeding has benefits for smallholder SR production, labour (especially women's and children's), and income, and is widely acceptable if local feeds are used
6. Anaemia in SRs is very widespread and needs further investigation of its causes, treatment and prevention. This high prevalence suggests that tick-borne disease could be widespread in SRs in Punjab and Sindh, and could have significant effects on animal health and production, and zoonosis risk
7. 'Outbreak' diseases such as PPR and FMD are widespread, despite government vaccination programs. The impact of these diseases on smallholders, the role of infection in their farms, and the reasons for current poor control and prevention need to be identified and rectified for smallholders' and sector benefit
8. A significant proportion of farmers have poor awareness of the animal specifications sought by SR buyers. Farmers commonly use visual assessment of weight but do not do so accurately, which disadvantages them when trading animals. Providing farmers with simple weigh scales improves their perception of success in SR trading.
9. There is no clear benefit to focussing on selling animals at Eid al-Adha, and more research is needed to detail costs, benefits, risks and opportunities of selling at different times of the year. Smallholder farmers need more comprehensive resources and training to ensure that they can trade SRs successfully at times that best fit their household needs as well as market opportunities.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The project achieved important scientific impact, although the extent of this was hampered by COVID-19 and the project's relatively short duration. The scientific impacts and outcomes from the project's Impact Pathway are shown in Figure 29 (noting that the approved Impact Pathway and Monitoring & Evaluation Framework focussed on outcomes more than impacts). Scientific impact was created through modelling inclusive research methodologies with staff, students, interns, collaborators, and participants that highlighted the importance of all family members' roles in SR production contextualized within the environmental and social opportunities available to smallholder families. Research collaborators from government and academia had direct exposure to the importance of practical and applied research methods used directly in smallholder farming systems for identifying opportunities and constraints for farming families. They experienced a research process that prioritised improving women's access to information, and which sought solutions using local resources that could be self-implemented and managed by smallholders.

Students and collaborators also gained experience in a data collection and analysis strategy that consciously sought to measure impacts of on-farm interventions on women and children, as well as delivering feedback and information directly to women (e.g. through the women's end-of-trial workshops). The project emphasized data collection directly from women, by women, as well as gender and age-disaggregated data analysis, and specific questions about impacts on women's labour and other traditional gender roles. We anticipate that students and collaborators will carry this practice into their future roles.

Four international or provincial institutions/projects adopted the project's participatory research approaches and early outputs, especially concerning creep feeding:

- The Australian Assistance to Agricultural Development in Balochistan Border Areas (AusABBA) project, a DFAT-funded program working in partnership with FAO in Balochistan, implemented creep feeding on a smallholder's farm in Balochistan and used this as a demonstration site for other farmers to learn the technique and implement it themselves. Based on the success of creep feeding, AusABBA started a dam feeding project that applied the project's creep feeding approach to breeding females.
- After the project's collaborative creep feeding trial on the Sindh Livestock Department's (SLD) Kamori goat research farm at Dadu, SLD independently expanded this approach to another creep feeding trial they initiated themselves on their sheep research farm at Kooka in Sindh. As a consequence of the Dadu research collaboration, the Kooka farm has also increased its research activities, which formerly focussed on buffalo, to cover sheep more.
- The United Nations Food and Agriculture Organisation (FAO) is using the FAMACHA anaemia assessment technique throughout their goat

Intermediate outcomes	Researchers, extension providers & small farmers have enhanced skills in small ruminant farming family approaches
	Small ruminant farmers have formed networks with researchers & extension officers to share experiences in value chain engagement & production
	Some research & extension organisations & leading individuals have adopted small ruminant farmers approaches
End of project outcomes	Some research institution & extension organisation officers have adopted small ruminant farmer approaches

Figure 29: Project Impact Pathway elements relevant to scientific impact

development activities in Pakistan after the project described use of the technique and findings of widespread anaemia throughout Punjab and Sindh.

- The ACIAR-funded project "Adapting to Salinity in the Southern Indus Basin (ASSIB)" has incorporated priority SR issues and research approaches from our project into their research program, and will use these at several of their farmer research sites. This includes adopting the approaches we have promoted for how to include SR farming systems in saline lands and water management research.

8.2 Capacity impacts – now and in 5 years

Project outcomes relevant to capacity impact from the project Impact Pathway are shown in Figure 30. The project has increased capacity of smallholder women and men farmers, community livestock workers, government staff, NGOs working in the Pakistan SR sector and community development, and researchers and academia. Capacity building allied to project research has covered topics including animal nutrition, health, and marketing.

The project developed and delivered multiple activities targeting technical capacity strengthening, as shown in Table 19, because major gaps were identified between smallholder farmers' disease knowledge and available support services for prevention or treatment. We also developed activities responding to direct observations of prevalent health problems that farmers wanted upskilling for.

Highlights of capacity impact include:

- **Project creep feeding activities increased farmers' ability to improve SR survival by about 33%, with greatest impact for women:** Of 220 farmers who participated in the Local Creep Feeds trial, the number who said that it was possible to improve the survival of young SRs increased from an average of 64% (53% of women and 76% of men) before the trial to 85% afterwards (77% of women and 95% of men). The total proportion who were unsure decreased from 27% to 9% after participating in the trial.
- 1051 farmers (545M + 506F) were trained in village workshops covering creep feeding and disease management at the end of the Local Creep Feeding trials in 6 villages in Sindh and Punjab. **More than 95% of women and men said they learnt new, useful techniques for SR feeding** through participation in the trial and workshops
- Of surveyed participants (n = 179), 29% of farmers and livestock workers said they would change their livestock husbandry following training in new resources or techniques produced by the project. The remaining farmers were unsure if they would change but no farmers said they would not change.
- **Fourteen Pakistan organisations have been trained in key SR topics, with nine using project information and training resources** with 690 next- and end-users (community development staff and farmers) to date. Trainees rated the usefulness of the information resources average 4.9 out of 6 (0: not at all useful to 6: extremely useful).

Intermediate outcomes	Leading women, youth and men small ruminant farmers have changed livestock management and marketing practises
	Women, men, youth small farmers have increased access to information and knowledge
	Women, men, youth small ruminant farmers are confident in technical knowledge and new approaches generated
End of project outcomes	Some small farmers especially women and youth are managing animals more productively and sustainably

Figure 30: Project Impact Pathway elements relevant to capacity impact

- **65% of farmer participants in the Pilot Creep Feeds Trial reported that they learnt something new** from being involved in the trial.
- Training material based on project findings or developed by the project has been **embedded in the curriculums of three university and government** farmer/animal health worker training centre courses and will be used in an ongoing basis

The Local Creep Feeds Trial created important capacity impacts through its participatory implementation and demonstrable benefits to SR production, including:

- Leading farmers in some villages are actively promoting creep feeding to other farmers in the area. Additionally, in some villages, farmers are purchasing green feed for their young goats after recognising that their nutritional needs were not met.
- Women have increased confidence and ability to fatten young animals. This is demonstrated by, for the first time ever in some villages, women selling their own animals at women-only livestock markets set up by NGOs and Livestock Departments.
- Women farmers have developed farmer leadership roles. For example, some women have spoken at National Workshops organised by the project and NGOs about how to carry out creep feeding and the effects it has on their households.
- Farmers have also increased their capacity to manage health of their SRs by themselves, with farmers in project villages directly reporting having better ability to vaccinate animals, quarantine sick animals, increase pen hygiene, and steps to follow in the face of disease outbreaks.

Other capacity impacts include:

- More than half of neighbouring households in the Pilot Creep Feeds trial, which did not directly participate, learnt something about creep feeding and were interested in trialling creep feeding themselves.
- 10 project staff (4M + 6F) have developed project management, organizational, administrative and digital skills, technical expertise in SR production and health, and applied research. Three staff now have government veterinary roles and one staffer is leading a new research project funded by ACIAR.
- 10 interns (5M 5F; 8 from UVAS and 2 from SAU) each undertook 3-month training placements with the project covering basic research methodology, qualitative and quantitative data collection, trial execution, practical field experience, scientific writing, and extension material development.
- 6 Village Assistants (local farmers or community animal workers) from Punjab and Sindh were employed and trained by the project in animal production and health monitoring, and data collection. They disseminated learned skills and knowledge to relatives and other farmers in their villages.
- More than 500 final year veterinary science students, 50 government Veterinary Assistants and 300 extension/farmer training staff from government, non-government and commercial organisations were trained in the project's animal monitoring techniques and approaches to participatory applied research.

> *"I am so happy by seeing the valuable changes in health of my sheep and goats, they got healthy even we have reduced the mortality rate. I am very much thankful to small ruminant project for building the capacity of farmers on a challenging topic. I will continue this technique in the future also".*
>
> **– Woman farmer who took part in a village training workshop delivered by the project for a women's development NGO in Sindh** (she also shared the knowledge with other female farmers for the better production of their small ruminants.)

Table 19: Details of capacity development activities conducted by the project

Date	Capacity Development Activity	Attendees	
		Women	Men
Oct-20	Applied research in SR Farming Systems	5	25
Nov-20	CommCare training for MPhil students	4	2
Nov-20	Applied SR research findings (DVM final year students UVAS)	25	45
Dec-20	Seminar on small ruminant project update	11	12
Mar-21	Sindh Livestock Expo: Body Condition scoring (BCS) & creep feeding	20	100
Mar-21	BCS for UpTrade Company staff and arranged a visit to Organic farms Kotri for practical demonstration of BCS on Animals	4	5
Mar-21	Research collaborator training for *Adaptation to Salinity in the Southern Indus Basin* (ASSIB) project: creep feeding & nutrition management	2	3
Apr-21	ASSIB collaborating farmers: SR husbandry training	4	20
Jun-21	WADO (NGO): BCS and creep feeding	11	14
Jun-21	Animal health worker training - Institute of Continuing Education & Extension (Punjab): Body Condition Scoring (BCS)	6	54
Jul-21	Sindh Livestock Department farm worker training (Dadu research farm): BCS & creep feeding	0	20
Aug-21	Sindh Agriculture University: training on BCS and creep feeding BCS and creep feeding training	0	40
Aug-21	Punjab Livestock & Dairy Development Department staff Workshop: BCS training at Livestock Training Centre (LSTC)	2	23
Aug-21	BCS training workshop for farmers at Punjab LSTC	2	20
Aug-21	Rural research engagement training model	20	25
Sep-21	DMK village, Sindh: Training on tick management for farmers	0	26
Sep-21	ASSIB National Stakeholder Workshop: SR applied research methods and husbandry methods	12	40
Oct-21	Creep feeding and BCS training – village women farmers, Sindh	30	0
Oct-21	SR husbandry for women: 14th Annual Rural Women Leadership Conference organised by PODA Pakistan	30	20
Nov-21	Creep feeding & BCS assessment: Science into Practice workshop for Sustainable Livestock Development Models (Islamabad)	9	31
Nov-21	National Farm Advisors Training Workshop: BCS & creep feeding	13	20
Dec-21	LSTC Okara, Punjab: One day training workshop on BCS	2	34
Jan-22	One day Seminar on Body Condition Scoring in Small Ruminants	8	42
Feb-22	UVAS, Jhang campus DVM students: BCS and Creep Feeding	22	102
Mar-22	Farmer feedback & training workshops for end of Local Creep Feed Trials (6 villages across Punjab & Sindh)	469	420
Jun-22	Pakistan Agriculture Expo 2022: BCS & creep feeding	50	150
Jun-22	Pakistan Agri Expo 2022: : BCS & creep feeding	45	150
Total		**785**	**1327**

8.3 Community impacts – now and in 5 years

Project outcomes described in the project Impact Pathway relevant to community impact are shown in Figure 31. The project has demonstrated impact in increased incomes of creep-fed animals sold by farmers. Importantly, creep feeding also clearly reduced the labour requirements of women, men and children caring for SRs.

8.3.1 Economic impacts

Both the Pilot and Local Creep Feeds Trials, which involved 157 households across Punjab and Sindh, demonstrated economic benefits for many participating farmers. In the Pilot Trial, creep feeding increased liveweights in Sindh and the majority of intervention households reported either receiving a better price, or having the opportunity to receive a better price, for the sale of creep-fed animals. The Local Creep Feeds Trial was implemented under a wider range of village and agroecological conditions across Punjab and Sindh, and still demonstrated an overall benefit to animal production and beneficial livelihood impacts to women, men and children raising SRs. The average increase in growth and survival of creep-fed animals compared to controls resulted in an average estimated extra net profit of 430 PKR/head (~$AU3.07 in 2021 prices) compared to traditional management, equivalent to about a 5–10% increase in net returns for animal sale price.

Greater actual economic benefits were obtained by individual women and men farmers who sold creep-fed animals. For example, a farmer in Saddiq Jatt (Sindh) said, *"I adopted the creep feeding technique and it proved very useful for me. I noticed the lesser mortality and higher growth rate of my kids even I sold the kids in higher prices than the adult goats. After adopting the creep feeding technique, I sold my kids in PKR 8,000 instead of PKR 5,000 before knowing about creep feeding".*

A woman farmer said, *"…after adopting the creep feeding technique, I observed the good health status of kids as now they feed their whole feed themselves in a creep area…I got good selling price of kids after adopting creep feeding and sold my one kid in PKR 20,000 which was, formerly, sold at the rate of PKR 8,000 before knowing creep feeding practice."*

The large majority of SR smallholder farmers continued implementing creep feeding beyond the project conclusion when they observed the increases in growth, survival and per-head value of animals. Ninety percent said they would continue creep feeding. This attests to farmers' perceptions of the economic and social benefits of creep feeding, and the sustainability of the intervention. During the project, this intervention was scaled out directly and through partner NGOs and government departments to about another 1,000 households. The FAO in Pakistan is also currently planning to train village livestock development workers for another 600 communities in project outputs, which could reach more than 50,000 households.

Although the economic impact was not directly measured, farmers who participated in project activities to help them weigh their animals reported that this also led to greater sale prices than usual. The majority of interviewees from the Pilot Creep Feeding Trial intervention group reported either receiving a better price or having the opportunity to

Intermediate outcomes	More women are participating in livestock value chain opportunities
	Small ruminant farmers are networked with value chain stakeholders
	Level of gender empowerment and benefit sharing in small ruminant livestock management increased
	Small ruminant farmers are networked with value chain stakeholders
End of project outcomes	Small ruminant farmers are receiving higher returns for livestock

Figure 31: Project Impact Pathway elements relevant to capacity impact

receive a better price compared to previous years or unfed animals.

8.3.2 Social impacts

The most significant social impact created by the project was the reduction in the labour of women and children managing kids and lambs by using creep feeding. The labour requirement of 80% of women and 86% of men who were involved in direct management of small ruminants was reduced or stayed the same by using creep feeding during the local feeds creep trial. Creep feeding reduced or maintained at previous levels the labour requirements of 100% (23/23) of girls and 93% (26/28) of boys in households where children directly contributed to kid and lamb management. In the years after the end of the project, it could be postulated that this would provide more opportunities for children to attend school or live more of a child's life. There is surprisingly little research published about the outcomes for children of labour-saving interventions in livestock production, and this hypothesis needs to be verified with impact assessment or more research.

As described in the capacity and economic impact sections, above, both men and women in control and intervention sites for creep feeding reported significant benefits from being part of the creep feeding trials. Farmers described benefits such as having improved knowledge of SR management and health (from the participatory nature of the trial and the post-trial training workshops), more power for selling their animals, improved survival and growth of their animals, and reductions in labour – most prominently for women and children.

An important supporting example is that women's participation in the Local Creep Feeds Trial at village Din Muhammad Kathio encouraged them to sell their animals in a new women's livestock market organised by the district government and a Sindh NGO, and reported by *The Guardian* in 2022 (see Figure 32). These outcomes led to social impact by empowering women farmers who historically had less agency or fewer access to resources.

There were important social impacts achieved by recognising and building on women's participation and knowledge. The project modelled gender inclusion to collaborators and participants through team staffing and training, student and intern recruitment, and data collection methods that sought out women's involvement in the research-for-development process. Male and female farmers, and some children, in several locations stated that seeing female technical staff active in field activities that supported farmer priorities made an impact on their understanding of women's capabilities.

The majority of women participants reported learning something from their involvement in the feeding trials, including health assessment knowledge, or management advice. An example of women's increased confidence is given in Section 8.2 in which almost half the women interviewed felt "unsure" about their ability to improve SR survival at baseline, increasing to 77% at endline—a 45% increase. The set of training modules and accompanying facilitator guide designed specifically for female farmers contains content highlighting women's important role in SR farming. This is linked to their existing informal knowledge on many aspects of household and family management, and has been provided to multiple organisations working in rural communities in Pakistan.

"During creep feeding field visit trial one of our registered farmers Khan Chand village was motivated by our female field officers to send his daughters to continue their schooling after primary education. On team's next visit for syndromic surveillance trial the farmer told female field officers that his daughters are now going to school for higher education after he sees our team members working in the field."

– Project Annual Report, 2020

"I wish to become a veterinary doctor as I am very much inspired by the hard work of the females working in the project, so that I may serve my village like these females in the future."

– Girl attending post-trial women's feedback workshop, Din Muhammad Kathio village 2021

8.3.3 Environmental impacts

The project did not directly measure environmental impact of its interventions, although it was hypothesised that increasing the efficiency of SR production by reducing wastage could potentially allow farmers to increase income from livestock without increasing the total number of animals they raise. The project established important links with the ACIAR ASSIB Project (see Section 8.1 and Table 19) and informed its research design to investigate how SRs could be sustainably incorporated into saline lands management.

One of our registered female farmer (treatment group) she sold the Kid in twenty one thousand for the first time, she declared that, "I wasn't able to go market to sell the animal before but since I got registered in your trial I learned many things by your project they made me such confident that I could approach the market and sold animal on my behalf."

Then we asked to her husband that are you satisfied with the selling price she sold on 21000? He replied that "I am happy to see that she sold the kid more than my thought. The kid had the low price but she sold in a good price, this spirit came from your project efforts."

– Farming family from village Din Muhammad Kathio, 2022

Figure 32: Female traders at Marui women's livestock market, Sindh, Pakistan ***(Source:*** *https://www.theguardian.com/global-development/2022/jan/20/for-the-first-time-i-felt-free-pakistans-women-led-livestock-market)*

8.4 Communication and dissemination activities

	Activity	Audience	Goal
Feb 2019	Research planning meeting	18 participants from 11 organisations	Coordinate project activities, look for collaborative project ideas and opportunities, identify resource and capacity gaps and develop an activity plan for next 6-12 months.
Feb 2019	Inception Workshop	39 participants from 17 organisations	Project planning & engagement
Sep 2018	Aishath project planning meeting	Project team & Sindh Livestock Department	Discuss project, SRA findings and collaboration opportunities
July 2019	Aik Saath project planning meeting	Project team & UVAS staff	Planning for the collaboration & linkage b/w different organization in possible activities, gender inclusiveness and M&E planning
	Guidelines for Raising Sheep and Goats module	Goat and sheep farmers, extension service providers, other stakeholders working with small ruminants	Share information on goat and sheep farming in Pakistan that would apply to smallholder and more commercial producers
	Study design plans	Punjab and Sindhi livestock department	Sharing creep feeding and longitudinal monitoring plans with the livestock departments to encourage participation
	Small ruminant health and production – Pakistan and Australia	UVAS staff and students	Guest lecture on project overview & findings to date
	Benchmarking reports	Control and intervention farming families involved in our creep feeding study	Individualised feedback to trial participants on growth and health of household's animals
	COVID19 stakeholder engagement	Registered farmers and stakeholders	Phone interviews with trial farmers about impact of COVID19 and provide project update
	Goat and sheep mortality events report	Punjab and Sindh Livestock Departments	Reports on health and mortality issues experienced by our farmers during COVID 19
	Project update	ACIAR chief executive officer, Andrew Campbell	Update on project results, activities and impact stories
Nov 2019	TropAG - International Tropical Agriculture Conference	International conference	Present conference posters
June 2020	6th World One Health Congress in Edinburgh	International conference	Present conference posters
Sep 2020	Meeting with Sindh Agriculture University researchers	Project team & university staff	To share the information of small ruminant project`s ongoing research activities, MPhil projects and how different MPhil students of the university can also get involve in research with the project

	Activity	Audience	Goal
Sep 2020	Project update - DVM students	DVM final year students Sindh Agriculture University	Update on SR sector applied research for veterinary students
Oct 2020	UVAS Small Ruminant Project Update & Future plans seminar	Vice Chancellor UVAS, Faculty members of UVAS and other stakeholders	To update the Vice Chancellor UVAS, Faculty members and other stakeholders regarding the small ruminants project`s ongoing and future research activities
Oct 2020	Project Mid Term Review	ACIAR review team, Vice Chancellor UVAS, Faculty members of UVAS and other stakeholders	To share the small ruminant project`s research activities performed in the first half of the project and upcoming plans and future activities
Oct 2020	Meeting with Sindh Livestock Department	DG (Extension), DG (Research), SVO (Senior Veterinary Officer), Director Animal Health of SLD (Sindh Livestock Department)	Share information about the small ruminants project`s ongoing activities in Sindh and planning for future collaboration and research opportunities
Nov 2020	Collaboration with Animal Production Department, UVAS	Project team & UVAS staff	Project team has engaged Dr Afzal and his postgraduate students in the discussion to enhance the small ruminant production
Nov 2020	Engagement with UpTrade	Project team leaders, Project team, UpTrade CEO and UpTrade staff	Discussion about the opportunities , mutual support and collaboration with for-profit livestock development company
Dec 2020	Project update seminar for Sindh Agriculture University	Vice Chancellor SAU (Sindh Agriculture University) , SAU faculty, Postgraduate students and Project team	An online seminar at SAU (Sindh Agriculture University), Tandojam to give project`s update and discuss the research opportunities
Jan 2021	Research trial planning at Sindh Government goat farm	Director General Livestock Extension , Sindh , Area Advisor Sindh (1 M)	To discuss about collaboration with Sindh Livestock Department by starting creep feeding trial at Kamori breed research extension farm , Dadu
Jan 2021	Engagement strategy with WADO (Women Agriculture Development Organization)	Focal lady WADO (Women Agriculture Development Organization) , 2 Area Advisors (1 M + 1 F)	Discussion on future collaboration prospects and project`s extension material dissemination plan
Feb 2021	Project updates and Collaboration with ICE&E (Institute of Continuing Education and Extension),UVAS	Director, ICE&E (Institute of Continuing Education and Extension),UVAS , 2 team members, Project Coordinator, Area Advisor (1M +1F)	To update about the project`s ongoing and future activities and discussion about future collaboration with Institute
March 2021	Coordination with Punjab Livestock Department	Director General Livestock Extension, Punjab , Director Animal Health, Lahore Division, ACIAR Pakistan Country Head, 2 Team members, Project Manager and Project Coordinator (1F + 1M)	Strengthen the coordination and collaboration with Punjab Livestock Department in research and extension activities
March 2021	Project updates and co-learning with Salinity project	Sindhi project team, Project coordinator, Salinity project team leads – by invitation of Dr. Bakhshal Lashari & Dr. Michael Mitchel	Presented an overview of the Small Ruminant Project. Plans are in place for the Small Ruminants project to advise the ASSIB project on experimental design and outreach to improve its relevance to livestock farmers

	Activity	Audience	Goal
March 2021	Collaboration with Sindh Livestock Department	Director General Livestock, Sindh , Project Coordinator (1M) , 4 Area Advisors (2M + 2F)	Discussion about the opportunities to collaborate with Sindh Livestock Department in most effective way and strategy for dissemination of project`s extension material
May 2021	Training plan and research collaboration with ICE&E	Lecturer, ICE&E (Institute of Continuing Education and Extension),UVAS (1F) , Project Coordinator (1M) , 2 Area Advisors (1M + 1F)	Development of end of training surveys for the farmers community and training plan for the veterinary associate class of ICE&E
May 2021	Project updates and opportunities for future collaboration with Punjab Livestock Department	Director General Livestock Extension, Director ICE&E (Institute of Continuing Education and Extension)UVAS (1M), Associate Professor ICE&E,UVAS (1M), Project manager (1F), Project Coordinator (1M)	To update about the project`s ongoing and future activities and discussion about future collaboration with Punjab Livestock Department
June 2021	MPhil projects and research opportunities	Assistant Professor Biochemistry (1M), Assistant Professor Microbiology (1M), Project Coordinator (1M), 2 Area Advisors (1M +1F)	Discussion about the MPhil projects and research opportunities for the post graduate students
	Engagement with various stakeholders about small ruminant resources	Project staff and scale-out partners (UVAS, AUSABBA, PODA, MDF, ECDI, ACIAR Pulses Project)	Share information sheets and modules with scale-out partners & seek feedback on content
Jan 2022	Meeting with D.G Livestock	D.G Livestock Nazeer Hussain kalhoro (Sindh) Area Advisors (2F), Senior Area Advisor (2M)	Update project`s ongoing and future activities and future collaboration with Sindh Livestock Department.
Feb 2022	Meeting with Sindh Agriculture University	3 SAU professors (3M) Dr, Saeed Soomro, Dr Moolchand Malhai and Dr Naeem Rajput Area Advisor (1F), Senior Area Advisor (1M)	Share research outputs, MPhil student research updates and plan training DVM students
	Meeting with Deputy Director Dr Mazhar Rind	Deputy Director (1M), Senior Area Advisor (1M)	To share the information of small ruminant project`s ongoing research activities, sharing of extension material, to invite the participating in end of trial village workshop
Mar 2022	Meeting with UNFAO	Project coordinator Jam Sehto (1M) SR project Coordinator (1M), senior Area Advisor (2M)	Update on project outputs & resources; discuss scale-out of project findings & resources through planned FAO community training & development activities
Aug 2022	Meeting with FAO	Dr Syed Noman, Dr Ali Kumbher, Senior Area Advisor (1M), Area Advisor (1F)	Sharing of project activities, extension material and planning for organizing one day training for the master trainers of FAO.

9 Conclusions and recommendations

9.1 Conclusions

Despite considerable potential and national prominence, the small ruminant sector in Pakistan continues to be constrained by significant wastage and inefficient production. The project described previously unreported details of many key components of this, including poor nutritional management, low growth, excessive mortality of young animals, sub-clinical disease including widespread anaemia, and a high prevalence of peste-des-petits-ruminants.

Women are important in SR farming: they perform most management of young animals and participate in decision-making, although men often control income from SR production in smallholder households. Farmers, especially poor communities and women, are disconnected from inputs and services that are necessary for efficient livestock production and trade, including technical information and training, and markets. Poor access to information places women in particular at risk of exposure to zoonotic diseases.

In general, although there are gaps in smallholder farmers' knowledge of key strategies to successfully manage SR production and health, they are information-seekers and know topics they want training for. Anecdotally, the project frequently observed that institutionalised misconceptions about farmers' ability to learn and bias towards large ruminant owners by service deliverers contributed to poor service provision.

Several simple interventions can effectively help overcome some of these constraints. SRs fed leguminous feeds in traditional smallholder farming systems have better survival than in households using other kinds of feeds. Since there is a wide variety of locally-produced feedstuffs available in many villages, selecting higher-quality feedstuffs to selectively offer to stock classes with higher nutritional needs (e.g. growing animals, breeding females) will increase survival and production. Creep feeding using local feedstuffs improves SR weight gain and survival, while also comprehensively reducing the workload of women and children who care for SRs. Creep-fed animals frequently sell for higher prices than traditionally-reared animals, and overall creep feeding is cost-effective when local creep feeds are used. Farmers can see the benefits of creep feeding once they test it themselves, and will choose to purchase more expensive feeds to use in creep feeding systems when they have spare money.

Smallholder farmers tend to be disadvantaged in trading transactions. The traits farmers focus on when preparing animals for sale and selling them are not well-aligned with those sought by traders. Farmers usually sell animals on a visually-assessed liveweight basis but these assessments are inaccurate and disadvantage their selling. Weigh scales are cheap and widely available, and farmers who weigh animals perceive themselves to be able to negotiate more successfully with traders and sell their animals for better prices.

These interventions are readily adopted by smallholder farmers, including women, especially when participatory training methods are used. It is critical that capacity development resources such as workshops and training materials are accessible to women; the project has comprehensively shown the effectiveness of this approach. This can be achieved by using literacy-appropriate formats, socially accessible settings for meetings and service delivery by other women. These approaches, combined with low-cost, practical interventions, can lead to strong, sustainable uptake by farmers that improves SR production, increases household incomes and strengthens farmer livelihoods.

9.2 Recommendations

This project achieved important impact, including successful scaling out through government departments, NGOs and international organisations, despite substantial disruptions by COVID-19 for most of its duration. The project's outputs and outcomes (including next- and end-user capacity building) should continue to be scaled out through existing networks such as NGO and FAO development programs. These should be delivered in forms that are accessible to women and men. The project has provided facilitator guides and examples of how this can be done that can be used directly by training and extension programs, incorporated into current curriculums, or used as a model approach to guide updates of existing work. Many of the project's outputs and training resources could be expanded to other regions of Pakistan beyond Punjab and Sindh, as already demonstrated in the AusABBA project in Balochistan.

The project showed that participatory, practical and continuous capacity development was particularly useful to farmers, and that women actively joined farmer training that was accessible to them. Despite very widespread farmer training and extension efforts in Pakistan, anecdotally we observed that there is little awareness of different adult education methods including empowerment and experiential action learning. Although the project and collaborators organically addressed some of these issues, there is an urgent need for more implementation (and research) of adult learning approaches in Pakistan's SR sector, backed up by the evidence base started by this project of the key constraints to SR production in Pakistan and practical, farmer-friendly methods to overcome them.

Several existing SR health issues need more investigation. Firstly, the causes of anaemia widely observed in SRs need to be identified. This could occur through simple veterinary investigations by field staff (government, NGO or university), or through more formal research. Investigations need to diagnose the cause of anaemia, its impacts on health and production, and practical ways smallholder farmers and others can treat and prevent it. Any work must acknowledge the potential role of zoonoses in the condition.

More broadly, currently there is poor awareness of key SR health issues at the district and provincial levels, with a disconnect between animal health workers and SR farmers. This limits the delivery of health services to farmers to improve productivity, whether through direct disease prevention and treatment programs, or farmer capacity development to manage SR health themselves. There is a need to strengthen capacity to diagnose SR disease and implement practical treatment and prevention, to at least bring it up to the standard of health service provision in the large ruminant sector. This could be supported by improved disease surveillance and reporting systems tailored to inform district- and province-level livestock health planning. Similar investments have been made in other countries but the magnitude of the effort required should not be underestimated.

More should be done to understand why there is a high seroprevalence of PPR in Pakistan despite current disease control efforts. We suggest this should focus on understanding the higher-level aspects of disease control, such as coordination and timing of vaccination programs, farmer and community engagement, and disease surveillance and reporting, rather than technical aspects of vaccine immunology or isolated seroprevalence studies, which seem to be the focus of some current research. This meta-understanding of PPR control in a diverse smallholder SR stetting such as Pakistan would provide critically useful support for the effort to globally eradicate PPR by 2030.

The project began to demonstrate effective ways smallholder farmers can engage better with SR value chains, but more practical research and scaling out is needed. An important bridge between this and the project's outputs could include expanding the principles of creep feeding (including feed selection) to fattening animals for sale. An entry point would be leveraging the preoccupation with fattening animals for Eid al-Adha, but the current gap between farmers' and traders' views on Eid market specifications and fattening for other markets should not be overlooked. More research is also needed into other methods smallholder famers can use to work with the rest of the value chain, and

identifying in more detail strengths and challenges further along it that could be addressed to strengthen the sector overall and deliver benefits to all participants, including smallholders.

10 References

10.1 References cited in report

Burton M, Fileccia T, Gulliver A, Qamar Kalim M, Tayyab A (2012) Pakistan: Priority areas for investment in the agricultural sector. Food and Agriculture Organisation of the United Nations, (Italy)

Campbell AJD (2010) Weaner Management. 'International Sheep and Wool Handbook'. (Ed DJ Cottle) pp. 277–294. (Nottingham University Press: Nottingham)

Campbell, A.J.D., Arif, Shumaila, ul Zia, Muhammad Atta, Hussain, Abdul, Doyle, R. E. (2019) Understanding the impact of on-farm animal wastage on productivity and livelihoods of smallholder goat farmers in Punjab and Sindh, Pakistan. In 'TropAg - International Tropical Agriculture Conference', Brisbane, Australia.(Brisbane, Australia)

Campbell AJD, Broekhuizen A, Curtis KMS, Croker KP, Behrendt R, Thompson AN (2014) A survey of post-weaning mortality of sheep in Australia and its association with farm and management factors. *Animal Production Science* **54**, 783–790. doi:http://dx.doi.org/10.1071/AN13149.

Campbell AJD, Vizard AL, Larsen JWA (2009) Risk factors for post-weaning mortality of Merino sheep in south-eastern Australia. *Australian Veterinary Journal* **87**, 305–312. doi:10.1111/j.1751-0813.2009.00457.x.

Cho MM, Htun LL, Aung A, Hlaing N, Campbell AJD, Glanville EJ, Hanks JE, Oo LN (2017) Effect of Creep Feeding on Live-Weight Gain, Coccidial Oocyst Counts and Haematological parameters in Goat Kids

Collins R, Dunne AJ (2015) Agriculture Value Chain Collaborative Research Program (AVCCR): Product Value Chain Assessments. Australian Centre for International Agricultural Research, (Canberra, Australia)

Dimagi Inc. (2022) CommCare Data Collection App. https://www.dimagi.com/commcare/.

Glanville EJ, Cho MM, Hanks JE, Thein SM, Oo KN, Aung A, Campbell AJD (2017) Strategic drenching and creep feeding - practical interventions to improve small ruminant production by smallholders in Myanmar. InSargison N (ed)(British Veterinary Association)

Hanks JE, Glanville EJ, Phyu E, Hlaing N, Naing Oo L, Aung A, Naing Oo K, Campbell AJD (2018) Using longitudinal syndromic surveillance to describe small ruminant health in village production systems in Myanmar. *Preventive Veterinary Medicine* **160**, 47–53. doi:https://doi.org/10.1016/j.prevetmed.2018.09.024.

Hocking Edwards JE, Gould RM, Copping KJ (2008) Putting Merino weaner management recommendations to the test. *Australian Journal of Experimental Agriculture* **48**, 974–978. doi:doi:10.1071/EA08003.

Larsen JWA, Anderson N (2000) The relationship between the rate of intake of trichostrongylid larvae and the occurrence of diarrhoea and breech soiling in adult Merino sheep. *Australian Veterinary Journal* **78**, 112–116.

Livestock and Dairy Development Department (2017) 'Livestock and Dairy Development - The Policy Papers.'

Morand-Fehr P (2005) Recent developments in goat nutrition and application: A review. *Small Ruminant Research* **60**, 25–43. doi:10.1016/j.smallrumres.2005.06.004.

Pakistan Bureau of Statistics (2017) Provisional Summary Results of 6th Population and Housing Census.

Saghir A, Chaudhary KM, Sharif M, Aftab R, Ashraf I, Ali S (2014) Gender and information gap in large and small ruminants with special context of neonatal care. *Journal of Agricultural Research* 8.

UNICEF (2011) Pakistan: Statistics.

United Nations (2017) World Population Prospects: The 2017 Revision. (New York)

United Nations Development Programme (2016) Pakistan Human Development Report.

WOAH (2022) WAHIS - World Animal Health Information System. *WAHIS Disease Situation - Crimean-Congo Haemorrhagic Fever*. https://wahis.woah.org/#/dashboards/country-or-disease-dashboard.

van Wyk JA, Bath GF (2002) The FAMACHA((c)) system for managing haemonchosis in sheep and goats by clinically identifying individual animals for treatment. *Veterinary Research* **33**, 509–529. doi:10.1051/vetres:2002036.

10.2 List of publications produced by project

Arif, Shumaila, Campbell, A.J.D., Dunn, T, Hussain, Abdul, Zia MA ul, Aziz, Abdul, R. E. Doyle (2019) Consumer Preferences for Goats & Sheep in Pakistan's Religious Meat Value Chain. In 'TropAg - International Tropical Agriculture Conference', Brisbane, Australia. 14.

Campbell, A.J.D., Arif, Shumaila, ul Zia, Muhammad Atta, Hussain, Abdul, Doyle, R. E. (2019) Understanding the impact of on-farm animal wastage on productivity and livelihoods of smallholder goat farmers in Punjab and Sindh, Pakistan. In 'TropAg - International Tropical Agriculture Conference', Brisbane, Australia.