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**Improving Dairy Value Chains in Pakistan
through Improved Extension Services**

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1 Acknowledgments

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- University of Veterinary & Animal Sciences, Lahore
- Livestock & Dairy Development Department, Punjab
- Livestock & Fisheries Department, Sindh
- Charles Sturt University, Wagga Wagga, Australia
- University of Sydney, Australia

A special thanks must go to our hard working field team from the University of Veterinary and Animal Sciences. Their dedicated, encouraging and passionate approach to extension and research made this project an enriching environment for all involved and every Australian team member, be they a senior researcher or fresh student, benefitted greatly from being involved.

2 Executive summary

This project was part of the second phase of the DFAT-funded Agriculture Sector Linkage Program (ASLP-2) in Pakistan and followed a 2.5 year dairy project that was part of the first phase of the ASLP program (ASLP-1). The project, with major activities in Punjab and Sindh, started in January 2011 and was completed in December 2015. The goal of the project was to enhance the profitability of smallholder dairy farmers in Pakistan through the development of widely-applicable dairy extension methods improved production and marketing of dairy products. Specific objectives were:

- 1) To determine the most effective manner in which the extension approach from LPS/2005/132 can be scaled-out with a lower level of direct supervision to different areas of Pakistan.
- 2) To develop and promote strategies for optimizing feed resources for small-holder dairy farmers.
- 3) To identify and promote new profitable strategies for calf rearing.
- 4) To identify and promote strategies for improving smallholder profitability through marketing opportunities of a higher quality product.
- 5) To build the capacity of future and current extension and industry personnel driving the production and marketing of milk from the farm to the consumer.

During ASLP-1 the dairy project focussed on improving the profitability of smallholder dairy farmers through the introduction of new extension approaches and materials. During ASLP-2 the extension program was expanded with an emphasis on the poor and marginalised producers. The project worked with men's and women's extension groups in each of 56 villages, totalling more than 1500 registered female and male farmers.

Key research outputs were:

- It was demonstrated that calf rearing strategies using native dairy breeds of cattle and buffalo can be highly profitable. This can be achieved by reducing mortality rates and increasing live weight gain by up to five-fold.
- A Kundi buffalo calf rearing trial showed that male calves can be successfully reared, weaned and grown to 4 months of age and subsequently sold for a handsome profit.
- Improved fodder seed varieties were introduced, providing opportunities to increase profitability four-fold for those smallholder farmers who choose to focus on forage and forage seed production.
- Trials of berseem clover, involving ICARDA and private seed companies (Pioneer and Jullundar), demonstrated that seed production can be increased three to four fold, and the production of fresh berseem fodder (fresh cut) enhanced by up to 40%.
- Through a PhD study assessing farm income and expenses, the project highlighted that 60-70% of smallholder farms with fewer than 6 milking animals are making no profit from their dairy enterprises.
- A study of milk quality showed levels of mycotoxins in raw milk were up to 45 times higher than those permissible in Europe, making it detrimental to human health. Maximum permissible limits for mycotoxins in animal feedstuffs and consequently milk need to be established and regulated.

A key outcome of the project was the development of a novel extension model, a whole-family approach, for Pakistan. This involved working with men and women farmer groups, and their children through a school program within the same village. This approach promoted learning and discussion about dairy topics in the younger generation which prompted actions back at home where children are often involved in farming activities. This whole-family approach to extension has shown that adoption rates can be doubled compared to working with just the male members of the household.

The team assessed the effectiveness of extension through a survey of three types of farmer participants: registered farmers (direct beneficiaries receiving intensive support on a monthly basis), unregistered farmers (indirect beneficiaries, neighbours/friends within the community), and traditional farmers control group, no link to the project’s extension program). This research showed that the biggest impact is achieved with registered farmers, unregistered farmers monitoring our program also experience significant impacts, but at lower extension cost (Figure 1).

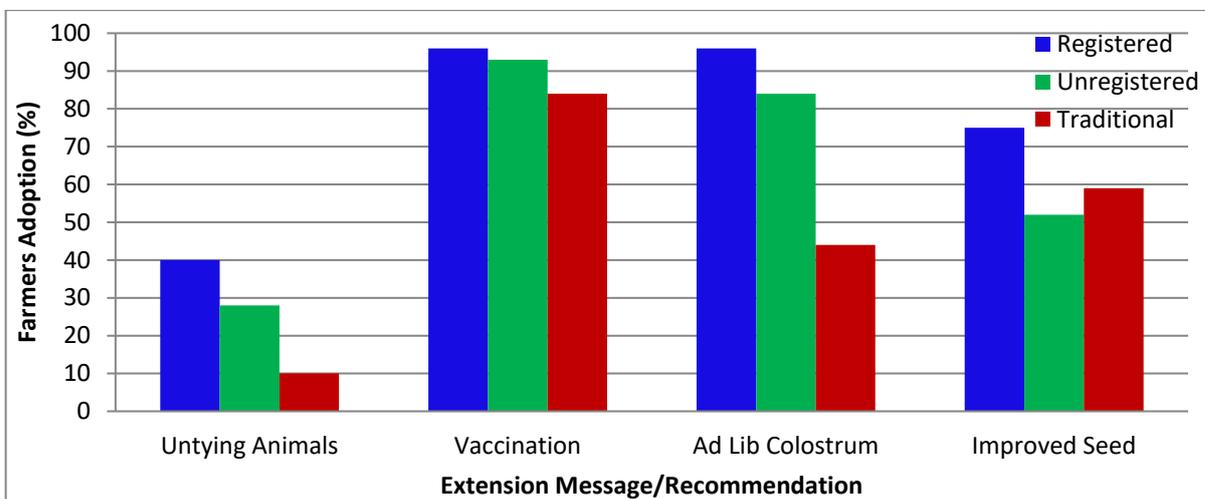


Figure 1: Adoption rates of four important extension messages by registered unregistered and traditional farmers (Total number surveyed, 399 across both Punjab and Sindh)

The whole-family approach to extension (with no incentives) resulted in adoption rates of greater than 80% with some messages among our 1500 registered farmer families with flow-on impact to over 3000 unregistered farming families. The extension message on free access of water through untying animals has been adopted by 40% farmers, and has resulted in a potential 25% increase in milk production per animal per day and also saving in labour costs, enhancing income up to PKR 9,500 per month. This extension model was extended to Khyber Pakhtun Khwa (KPK), the Federally Administered Tribal Areas (FATA) and Balochistan through three training workshops for extension workers from these areas.

Demonstration plots of fodder legumes and maize were planted using quality seed provided by two private seed companies. By adopting the key agronomic recommendations for berseem, farmers made an extra PKR 25,000 (AUD 315) in profit per acre cultivated, while also accumulating additional benefit from higher nitrogen levels and increased soil fertility which reduced the cost of production of the next crop by PKR 5000 (AUD 65) per acre.

In early 2012 a calf rearing competition for children was run in the district Pakpattan with 13 families from 5 villages to see what growth rates can be achieved under village conditions, using the project's fact sheets on calf rearing. The competition revealed that these animals could reach growth rates of more than double that seen in many research institute trials, and contributed to many farmers (average adoption rate ~70%) taking ASLP recommendations on board for their own farms.

The dairy project introduced milk value addition strategies in some villages which have become very popular among female farmers with ice-cream and cream extraction providing opportunities for small entrepreneurship models to be developed, increasing income by up to three fold per litre. Introduction of community-based milk selling systems and group marketing strategies has resulted in 8 groups, consisting of a total of 35 farmers, receiving a 40% increase in the price for their milk.

Capacity building was a cross-cutting activity throughout the project.

- Eight PhD and fourteen Master's students (Pakistani as well as Australian) were trained and carried out their research on the challenges relating to profitable smallholder farming enterprises. Outcomes of their research were incorporated into the project's extension materials.
- Ten extension training workshops were organised for selected extension workers from the government livestock departments of Punjab and Sindh. An assessment of the impact on extension staff showed that ASLP trained extension workers performed substantially better than control group extension staff in their field extension activities.
- The Dairy Project facilitated three student forums involving Australian and Pakistani students working together in Pakistan, including students from all twelve Veterinary schools across Pakistan.
- The project's internship program has been rated as one the top choices among veterinary students across the country due its multidisciplinary training approaches and long term career development opportunities. Overall 35 internship students from both Punjab and Sindh have participated.
- Six members of the Pakistan project team have been awarded highly regarded fellowships and scholarships, including one Fullbright Scholarship to study in the USA and three John Allwright Postgraduate scholarships.
- The project has organised four trainings in Australia to provide international exposure to young professionals from the dairy and meat industries of Pakistan. In addition, project team members have presented their research work in more than twenty-five national and international conferences.

The project developed, from new primary information, a complete package of extension material for the small-holder dairy farming systems of Pakistan which is comprised of 10 modules and 25 fact sheets. The team has completed translating the project's extension material into the Sindhi language to help with dissemination among farmers and extension workers in that province.

Eleven peer reviewed papers have been published and 20 papers presented by project staff at international conferences. An innovative fodder and feed calendar was produced to communicate best agronomic and feeding practices with farmers. This was adopted and disseminated by other organisations in Pakistan, including Nestle and Universities such as Sindh Agriculture University, which translated the information to Sindhi language.

To help propagate the positive impact of the project the team collated a case study booklet highlighting the success of some of the project's exemplar farmers. This booklet outlines some of the benefits our farmers have seen by implementing the project's recommendations.

A final project forum was successfully carried out on 14 October, 2015. This forum invited participants from dairy sector stakeholders from all over Pakistan including the University, private, NGO, aid and Government sectors. The forum was a highly successful one in which participants were able to visualise the dairy extension approach, hear first-hand impacts of on-farm activities to household incomes and then were able to interact with the scientists that carried out the applied research initiatives which fed into the extension program.

3 Background

The population of Pakistan has increased from est. 65 million (1972)¹ to an estimated 169 million (2010) (GoP), and is forecast to increase to 234 million by 2025. Within the Pakistan economy, agriculture, including livestock, is the largest sector. With the increasing population pressures, rural development, based around productivity gains in food and livestock production, is important for food security and crucial to poverty alleviation. The bulk of agricultural and livestock production comes from small household farms that are owned or tenanted, with landless families also rearing livestock. The rural population engaged in livestock production has been estimated to be 36 million (Economic Survey 2008/09), and these farmers/households derive 30 to 40 % of their income from livestock. Services to the dairy sector are provided by Provincial and District government agencies and a range of NGOs: virtually all service providers who interact with the farmers are veterinarians or para-veterinarians who administer vaccines and drugs and undertake artificial insemination for buffalo and cattle. It is essential to note that only 40% of farmers receive some form of support from the State Livestock Ministry. The most important deficiency arising from this process is the lack of extension workers with experience that crosses the nutrition-reproduction-disease management, farm economics or whole farm management interface. In essence preventative veterinary medicine is a foreign art to these farm extension workers.

Pakistanis prefer high-fat milk, mainly produced by buffalo, with milk and/or dairy products currently providing more than half of the animal protein available for each person daily: nearly 30 % of household expenditure on food items is on milk and dairy products. National milk production has been increasing at about 5 % per annum, exceeding 33 m t in 2008, (FAO), from around 12 m t in 1990. This sustained growth has been achieved by more than doubling the population of milking animals over that period to 33.7 m buffalo and 38.3 m cattle (in 2012-13), with buffalo increasing at a greater rate, and by adopting better feeding practices and animal health management. It is these 2 latter areas that require rapid development as currently know-how at the farm level is rudimentary. Small-holder milking herds comprise both buffalo and cattle in different proportions depending on location and markets, with cattle used to maintain year-round production. However, milk supply does not match domestic demand, and with the projected population growth, the deficit between domestic supply and demand for milk is expected to grow.

The majority of dairy farmers fall into the subsistence farms category producing milk solely for consumption in the home, whilst most of the remaining dairy farmers manage rural market-oriented farms (selling excess milk locally for a small profit). Over 70 % of buffalo and cattle are in herds of less than 10 animals; about 70 % of households with milking animals have herds of less than 5 animals, while a further 20 to 25 % of households own 5 to 10 animals. Commercial dairy operations are becoming more popular in Pakistan, and this is likely to drive a further need for progress and more efficient production systems in the small-holder dairy farms.

In 2005, the Government of Pakistan identified the dairy sector as one of the key focal points in which Australia has a comparative advantage and could build significant linkages

¹ http://www.statpak.gov.pk/depts/pco/statistics/pop_by_province/pop_by_province.html

and thus aid in the development of the industry. From August 2007 through to April 2010 funding under the DFAT-funded Pakistan-Australia Agriculture Sector Linkages Program (ASLP) was utilised to address industry constraints through LPS/2005/132 "*Improving Dairy Production in Pakistan through Improved Extension Services*". The objectives of LPS/2005/132 were to (1) Develop effective extension material targeted to specific topics of importance to improving milk output from information currently available from within Pakistan, (2) Measure gains in productivity on small-holder dairy operations through improved extension services by conducting a longitudinal survey of co-operating farmers in a relatively well developed and an underdeveloped region of the Punjab province, and (3) Facilitate the building of workable linkages between personnel across the animal production spectrum both within Pakistan and between Pakistan and Australia with an emphasis on the development of the next generation of dairy production and extension workers. An external review of LPS/2005/132 in November 2008 considered that, while it was the shortest of the four ASLP projects (running for 2.5 years), it had progressed satisfactorily, and showed considerable promise to deliver robust outcomes. It could be further strengthened through a broader appreciation of extension delivery for both dairy and non-dairy components of the smallholder farming system.

A second phase of the ASLP program was developed following the drafting of the Pakistan-Australia Agriculture and Rural Development Strategy (PAARDS) 2010-2014. The overarching objective of Australia's aid support to Pakistan under PAARDS (2010-2014) was to collaborate strategically to improve livelihood systems for the rural poor in Pakistan. This resulted in a second phase of ASLP (ASLP 2) which was implemented by ACIAR through three components: Pro-Poor Value Chains (PPVC); Agricultural Capability (AC); and Enabling Policy (EP). Most support was provided for Pro-Poor Value Chain projects that extended the outcomes and collaborative linkages of ASLP-1 while, at the same time, integrating with personnel responsible for the AC and EP components of PAARDS.

LPS/2010/007 was developed in this context and through close in-country consultation between collaborators from Pakistan and Australia. The following researchable issues were continued to be pursued:

- **extension methods** - LPS/2005/132 demonstrated the potential of new extension approaches and materials in the Punjab and the challenges in applying these within three contrasting organisations. LPS/2010/007 focussed on the specific success stories of LPS/2005/132 and selectively tested them throughout Pakistan, assessing their utility for enhancing pro-poor benefit flows.
- **nutrition of lactating animals** - LPS/2010/007 refined management strategies for fodder production and the identification of alternative year-round feed sources.
- **calf rearing** - LPS/2010/007 focussed on increasing the efficiency of the whole production system by reducing pubertal age and ensuring male calves were grown out for meat production
- **marketing** - LPS/2010/007 investigated marketing options for small-holder dairy farmers to achieve greater financial returns from their product. A major focus of the LPS/2010/007 project was to disseminate our extension methods refined under LPS/2005/132 into different regions of Pakistan. This involved the provision of further skills in communication and leadership for our team of veterinarians, who then were capable of adopting the role of a farm management advisor rather than simply providing traditional veterinary medical practice. The further development of

skills in organising effective farmer training days was a high priority. The fostering of effective extension teams rather than individual operators within a region was achieved in many of our project sites during LPS/2010/007.

4 Objectives

Goal

To enhance the profitability of smallholder dairy farmers in Pakistan through the development of widely-applicable dairy extension methods improved production and marketing of dairy products.

This goal was addressed by five objectives, arranged under three themes:

Theme 1: Testing and enhancing dairy extension approaches throughout Pakistan.

Objective 1: To determine the most effective manner in which the extension approach from LPS/2005/132 can be scaled-out with a lower level of direct supervision to different areas of Pakistan.

Theme 2: Research priority areas for enhancing milk production and quality from smallholder dairy farmers identified under LPS/2005/132.

Objective 2: To develop and promote strategies for optimizing feed resources for small-holder dairy farmers.

Objective 3: To identify and promote new profitable strategies for calf rearing.

Objective 4: To identify and promote strategies for improving smallholder profitability through marketing opportunities of a higher quality product.

Theme 3: Capacity building of dairy extension and industry staff to implement the improved dairy extension approaches.

Objective 5: To build the capacity of future and current extension and industry personnel driving the production and marketing of milk from the farm to the consumer.

5 Methodology

The underlying methodology used within this project was to use the outputs and findings of the ASLP-1 dairy project, further refine the extension approach and then implement and evaluate an 'improved extension model' in a number of different locations across Pakistan. This was carried out in five districts in Punjab (Okara, Pakpattan, Kasur, Bhakkar and Jhelum) and two in Sindh (Thatta and Badin). The extension work was implemented with our project collaborators from the University of Veterinary and Animal Sciences (UVAS) and the Livestock and Dairy Development Departments (LDDD) of both Punjab and Sindh. Extension staff from these organisations were trained, guided and supported by the project team to carry out a dairy extension program using a whole-family approach to training, including the women and children, which we refined as our program progressed.

The evaluation of the extension model looked at two key areas:

- The impact of extension services on production, profitability and animal health at the farm level of three different farmer groups; (1) registered farmers (direct beneficiaries), (2) unregistered farmers (indirect beneficiaries) and (3) traditional farmers (with no link to the extension program) who acted as the control group.
- The impact on the extension workers who we adopted as our trainees from the LDDD. These field staff were given on-going learning and training throughout the project. The impact of this program on their capabilities and the sustainability of the program within their employment organizations was important for the program.

To implement an effective extension program, the project devised three major components running concurrently;

- An extension model (addressing Objective 1)
- Applied research (addressing Objectives 2 & 3 & 4)
- Capacity building (addressing Objective 5)

These components were closely integrated, building on one another, as the research project matured. The extension model required the incorporation of applied research findings into extension material that was then the subject of capacity building workshops for the team. Careful reflection on the impacts of advice offered to farmers formed an integral part of the program. The relationship of these components is presented in Figure 2 as developed by one of our teams in a workshop.

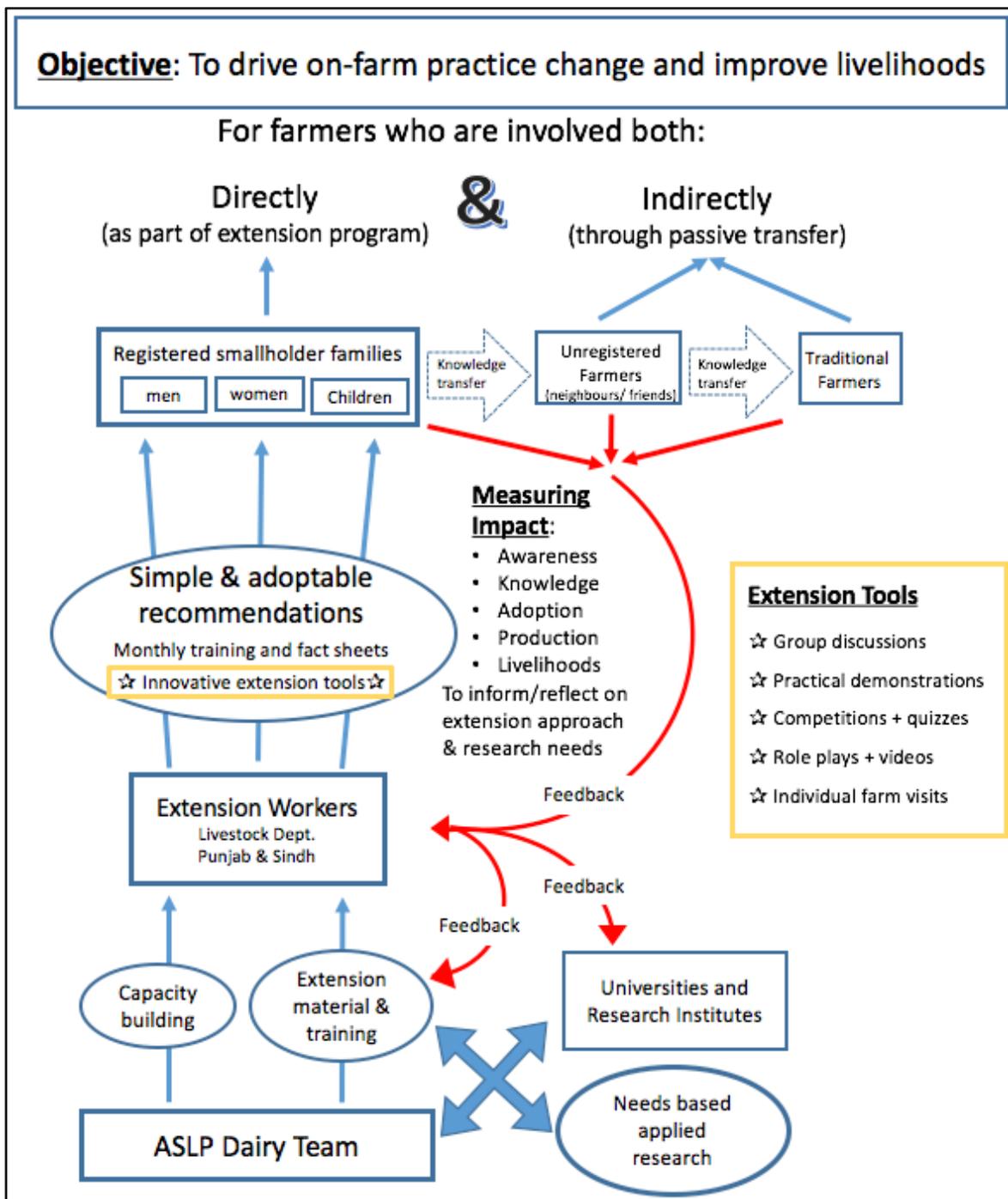


Figure 2. Diagram showing the main components of the ASLP Dairy Extension program.

Extension model

The extension model evolved through a number of steps, firstly to establish the program and then develop interesting and innovative activities to build working relationships between the farmers and extension workers: the evaluation of the impact of the extension program was an important last step. These steps are now described in detail.

1. Selection of extension workers (EW)

- The project has collaborated with the Livestock Departments of Punjab and Sindh due to their wide network of veterinary officers across the country. The project team selected young and motivated EW from Livestock Departments to join our

extension program. EW were selected on the basis of their professionalism, extension aptitude, social linkages, communication skills and their ability to lead.

2. Selection of villages in clusters

- Villages were selected in clusters to replicate the way an extension program would generally be carried out. That is, with one extension worker attending to a number of villages in a cluster within their area.
- Village selection was carried out in collaboration with the local extension workers and relied on their knowledge of the villages and the people residing within. This process also considered the number of market-oriented smallholder farmers, the dairy animal population and road access.
- For naive entry into new villages, the connections and trust had to be built first before establishing an effective extension program.

3. Regular training and program evaluation

- To train the EW to implement the extension program, a three-day workshop was conducted every three to four months. The workshop provided a training program on the current needs and challenges of the farmers and the next extension module that would be presented in the farmer discussion groups. These workshops always involved research experts, to help convey the important aspects of current research on the topic. Reflection on the effectiveness of interactive learning experiences including field trips, problem based learning and novel communication methods formed an integral part of each workshop.
- An evaluation of the progress made by each EW and of the extension program in general was also a part of these regular meetings. At this stage EW, the project team and Livestock Department management had an opportunity to provide feedback, encouragement and recommendations for improvements in the program.

4. Community Mobilisation

- After selection of EW and villages, project staff working with the EW initiated contact with the farming households of that village. This involved inviting farmers to attend information meetings with the objective of establishing a farmer discussion group in each village.
- An important part of this process was engaging with the women in farming families and also establishing a female farmer discussion group to run concurrently with the men's group. Children were encouraged to attend either of these meetings as were their school teachers. The project called this the "whole family approach" in which males, females and their children were involved in regular training sessions and farmer discussion groups. The aim of these sessions was to stimulate informal family discussion of the practicalities of adoption of recommended practices on farm to boost family welfare. However, at no stage were financial incentives provided by the project to facilitate the adoption process.
- Following this a 'farm registration' data base was initiated to keep records of the farmers involved as well as to track their progress throughout the project.
- More detail of this process is outlined in the project's extension model on 'Community Mobilisation'.

4. Extension material.

- One of the key outputs of the ASLP-1 dairy project was the collation of research outcomes from Pakistani institutes, and refining them into practicable extension messages targeted at smallholder dairy farmers.
- In the ASLP-2 dairy project this material was further refined and ten modules were developed. Each of these modules contained an EW booklet and two or three farmer fact sheets. The EW booklets were targeted at the field officers and contained farm recommendations with simple yet detailed explanations to help EWs convey the messages to farmers. The farmer fact sheets were single, double sided A4 sized coloured cards with just the basic farm recommendations, alongside pictures and diagrams to help explain the messages.
- The farm recommendations in the extension material were essentially research outcomes (from previous research or ASLP applied research) transformed into simple, adoptable and impact oriented extension messages. The focus again was to convey messages to smallholder farmers, to address their need to improve the profitability of their livestock enterprises.
- The project's extension material so far includes a feed and fodder calendar, 10 training extension modules and 25 fact sheets in Urdu and Sindhi languages. The 10 extension modules are:
 - Cow Comfort/Animal Husbandry
 - Animal Nutrition
 - Animal Reproduction
 - Calf Rearing
 - Animal Health/Disease Management
 - Ration Formulation
 - Dairy Breeds and their Selection
 - Milk value-addition
 - Improved fodder agronomic practices
 - Community Mobilization.

6. Monthly dissemination to farmers

- New extension material produced by the project was disseminated to farmers every four to six weeks (depending on farmer availability and season). This was carried out through farmer discussion groups. The advice from farmers on the most appropriate topic for future sessions was adopted and mostly related to their needs according to the season of the year.
- Farmer discussion groups were carried out with two sessions running concurrently; the main male farmer discussion group, coordinated by the local LDDD EW collaborating with the project, and the female farmer discussion group. These consisted of the partners from the families of the males in the male farmer discussion group. The female farmer groups relied heavily on a 'focal woman' to organize and advertise the meeting which was then facilitated by project staff (UVAS employees).
- As part of the farmer discussion groups the project team used various innovative extension tools including quizzes, role plays, model farm visits and audio-visuals. Other associated activities included farmer festivals and calf rearing competitions. These all created better farmer understanding of extension messages and enhanced participation in extension activities. Importantly the 3 elements of the family were involved, the farmer, his female partner(s) and the children.

- More than 1500 registered farmers (direct beneficiaries) were engaged in the project's extension program across the seven project districts.
- Other than the farmer discussion groups, extension staff and project team members engaged in one-on-one visits to farms to help farmers discuss their individual challenges and encourage them to adopt recommendations that were applicable to their farming system.

7. Marketing strategies

- As the project progressed, increases in milk production were being observed, but selling milk and receiving an adequate price continued to be a constant challenge. To address this, the extension team incorporated a section of the extension program to explore possible milk value addition strategies. This helped farmers with more options to add value to their primary product, or to obtain a higher price for their milk.
- A module on milk marketing and value-addition was produced; this gave farmers an opportunity to see how farmers in other regions had increased the value of their product. Farmers were then able to discuss how these marketing options could be adopted as a part of their own enterprise.
- Among the ideas discussed, activities relating to value-addition have become very popular among female farmers, with ice-cream and cream extraction providing opportunities for small entrepreneurship models to be developed. This has enhanced their income by up to three fold per litre. Many other communities have been motivated by seeing these activities and are now following these successful models.

8. Monitoring & Evaluation

- Throughout this extension program, the project captured data and stories to help monitor and evaluate the progress of farmers and the extension team. The four main components of this were:
 - Farmer case studies to highlight stories of change on their farms. These were collected throughout the project as success stories relating to adoption or farming management were shared with team members.
 - Longitudinal data from a subset of registered farmers to track progress over time in terms of milk production, animal numbers and farm management practices. These data provided valuable information to add depth to farmer case studies while providing continuous feedback to the extension team to discuss at training workshops and to formulate future applied research initiatives.
 - Impact assessment survey. Assessing the impact of the extension program was a key aspect of this research. Peter Horne (ACIAR) helped guide the team by providing ideas on how to capture impacts at a farm and project level. In January of 2014, a survey of the three different farmer groups established in our program. These groups were; (1) registered farmers (direct beneficiaries), (2) unregistered farmers (indirect beneficiaries) and (3) traditional farmers (with no link to the extension program) as the control group. By comparing the knowledge, understanding and subsequent adoption rates of these farmer groups, a clear evaluation of the project's impact was determined.
 - An evaluation of the impact of project's extension worker training on the knowledge, communication skills and self-confidence of LDDD veterinary staff

engaged in the project's extension program. This involved a series of assessments of treatment (project trained) and control (other LDDD veterinary staff) extension workers. These assessments were conducted by an internal and external reviewer in mid-2014.

Applied research

As outlined previously, the majority of the extension material utilised in this project is based upon previous international or local research. However, in a number of areas, applicable research was not available and hence there was a necessity to carry out needs based research to address specific smallholder dairy farm challenges. This was an important part of the overall extension program as it provided valuable, current information to share with farmers to help them improve their farming system. The focus of this applied research was based on:

- Farmer feedback gathered throughout the extension program;
- Feedback from the project's Nutrition Focus Group and other expert workshops;
- Results from farmer surveys;
- Opportunistic research activities which addressed new and immediate challenges.

The project conducted these applied research activities in collaboration with Universities and research institutes across Pakistan; and in most cases involved students from either Pakistan or Australia. Three of the key research areas addressed primary challenges that arose from the work outlined in the ASLP-1 project; around nutrition, calf rearing and milk marketing. An outline of this research as well as other areas addressed by student projects is described below.

- Nutrition, fodder and feed related research
 - A large component of this work was focused around the provision of sufficient high quality fodder to fill seasonal feed shortages. This was led by Shoaib Tufail (CSU PhD student) who incorporated this research into his thesis entitled "Development of village-based forage seed enterprises (VBFSEs) for the profitability and sustainability of smallholder farmers of Pakistan in mixed farming systems". Shoaib focused on (1) comparing the productivity of improved and local Berseem clover varieties, and refining local agronomic practices for growing Berseem clover in smallholder farmers' fields and (2) establishing village based forage seed enterprises (VBFSEs) as a means of increasing the distribution of improved varieties of Berseem clover forage seed and providing another commercial opportunity for farmers.
- Calf rearing research
 - The effect of weaning age and milk feeding level on pre- and post-weaning growth performance of Sahiwal calves. Carried out by Master's student A. Cheema of the University of Agriculture Faisalabad (UAF) under the supervision of Dr Shaukat Ali Bhatti.
 - The effect of weaning age and milk feeding level on growth performance of Nili- Ravi buffalo calves up to the age of 16 weeks. Carried out by UAF Masters student W. Abbas under the supervision of Dr Shaukat Ali Bhatti.
 - Comparison of growth rates and health of Kundi buffalo calves fed cow's milk or buffalo milk from birth to weaning. A key aim of this work was to assess the cost of production for each kilogram of live weight gain and to showcase the

- profitability of this practice. This work was led by Dr Amir Solungi (Sindh Agriculture University Tando Jam) and four Master's students.
- A calf rearing trial involving orphaned buffalo calves procured from local animal markets. The objective of the trial was to identify effective and adoptable alternative colostrum feeding strategies given that animals purchased from local markets may not have been reared and fed very well in their first few days of life. This project was carried out at the UVAS Ravi campus under the direction of Dr Muhammad Afzal (UVAS).
 - Milk marketing and quality related research
 - Sosheel Godfrey (a CSU PhD student) investigated different aspects of the milk marketing chain in Pakistan including (1) costs of production to farmers and how their herd size related to milk price and their overall farm profitability; (2) identifying producer, middleman, retailer and consumer issues from a pro-poor value chain perspective and outlining the 'informal milk value chains' from the urban consumer's perspective; and (3) milk value chain analysis, industry competitiveness and the dairy policy environment of Pakistan
 - Naveed Aslam (a CSU PhD student) investigated the prevalence and impact of mycotoxins in animal feed and implications for the milk supply chain and the end-consumer.
 - Other research conducted by numerous higher degree students played an important role in the capacity building component of the project as well as providing valuable input for extension material and training.
 - David McGill (a CSU PhD student) completed his research on the Sahiwal progeny testing system and has carried out an important study on breeding objectives involving academics, breeders and farmers to help expand on the current selection program.
 - Muhammad Riaz Khan (CSU Masters student), who received a grant from the Bill and Melinda Gates Foundation, carried out research on ways to increase reproductive efficiency in dairy buffaloes within current production systems in villages of the FATA.
 - Thomas Williams (a CSU PhD student) started his research in early 2015 investigating endoparasites in buffalo in Pakistan. His project is assessing current practices to manage parasite loads, as well as surveying the parasite species and level of infection in buffaloes at project registered farms.
 - Sahibzada Shafiullah Khan (a CSU Masters student) developed an assessment tool to analyse the productivity and financial viability of dairy farms in Pakistan. He has continued as a PhD student to investigate risk factors for antimicrobial resistance in humans and animals in the Riverina region of Australia.
 - Shumaila Arif (former project team member and now a CSU PhD student) is conducting a concurrent epidemiological study on brucellosis in Pakistan. Her research involved taking blood samples from dairy animals from project areas and comparing prevalence, with risk factors on-farm, which will inform a participatory epidemiological education program to increase awareness about zoonoses.
 - Sajid Latif (former project team member and now a CSU PhD student) is working on the metabolomics of a potential new fodder species (biserrula). His project is designed to identify specific bioactivities present in fresh and/or dried

tissues responsible for photosensitisation and/or weed suppression, both of which are important properties of this legume.

Capacity building

Training and capacity building was a cross-cutting theme of the project and the focus of every extension and research activity. The main capacity building activities included:

- Pakistani academic workshops and applied research support; carried out in collaboration with Australian academics providing input and on topics related to the needs of farmers and researchers themselves. Examples include:
 - Ration formulation (Dr Gaye Krebs, CSU, March 2013).
 - Biostatistics for researchers (Dr Peter Thomson, USYD, October 2013).
 - Nutrition Focus Group meetings (Dr Russell Bush, USYD, 2011-2013).
 - Breeding objectives for dairy animals (David McGill, CSU, October 2013).
- Project team workshops and meetings to reflect and refine the extension model.
 - Novel extension approaches (Michael Campbell, CSU, February 2012).
 - Impact assessment methodology (Peter Horne, ACIAR, October 2013).
 - Biometry for researchers (Peter Thomson, USYD, October 2013).
 - Writing workshop (Cassily Charles, CSU, September 2014).
 - Photography workshop (Mayfly Media, September 2014).
- The extension worker (LDDD veterinary staff) training workshops (every 3 to 4 months).
 - As outlined in the 'Extension Model' component, the project organized on-going workshops on the whole dairy farming system. After every training workshop the extension worker conducted field activities and farmer discussion groups in selected farming communities.
 - An important part of this capacity building was that community members provided feedback to the extension worker which was helpful in revising our extension services.
- Farmer discussion groups (monthly) which involved the dissemination of extension material by LDDD extension workers (outlined in the 'Extension Model' component).
- Training of KPK and Balochistani extension workers in the Extension Model.
 - This was carried out in 3 workshops each of 3 days duration over the course of a year. The aim was to expand the project's activities to these two additional, important provinces. This training was much shorter and more intense than the on-going capacity building provided to the LDDD staff from Punjab and Sindh.
- Research student involvement from both Australian and Pakistani Universities.
 - As outlined in the 'Applied Research' component many students were involved in each research activity. This not only helped provide input to reach project objectives, but it also provided valuable hands-on experience for the students.
 - University Student Forums were used to engage all Veterinary Universities from across Pakistan and link them with visiting Australian researchers and students. The aim of this was to establish a community of young researchers interested in addressing the challenges facing smallholder farmers and seeing how applied research can be used to do this.

- The internship program.
 - The project linked in with the internship programs of UVAS, UAF and SAU. Each year a small group of students varying in number from 2 to 8, were selected; depending on their availability and the needs of current research projects.

The aim of this was to build stronger links with each of the Universities and to help develop and train early career veterinarians in the importance of applied research and extension. This process was also used to identify individuals that showed the potential to join the project's extension team, or conduct further studies linked to the project.

6 Achievements against activities and outputs/milestones

Objective 1: To determine the most effective manner in which the extension approach from LPS/2005/132 can be scaled-out with a lower level of direct supervision to different areas of Pakistan.

no.	activity	outputs/ milestones	completion date	comments
1.1	Critically analyse the LPS/2005/132 extension program and the results achieved from the longitudinal survey of farmers	Publication of the key results from the ASLP-1 survey	Analysis 2010/2011	Data collected during the ASLP-1 project was partially analysed. However, the database held a lot of information and the team utilized various aspects of it and compared the data with the information collected during the ASLP-2 period. For example our staff/students prepared three publications utilising data from Phase- I relating to calf rearing, whole farm profitability and quantitative genetics. Developed success stories booklet of the farmers who have adopted our recommendations and their impact on their livelihood.
		Three papers presented by the dairy team at 15th AAAP International Conference in Bangkok, Thailand	Publication 2012 Nov 2012	
		Field tour and review by Australian and Pakistani experts leading to project implementation plan for Phase- II	2010	
		An updated extension approach following a team based ASLP-1 extension program review	Jan-Mar 2011	A review assessing the effectiveness of the extension program of Phase-I lead to a greater focus and involvement of women in farmer discussion groups. This lead to the establishment of the 'whole family approach' to extension.
1.2	Through consultation with key stakeholders, define less intensive and more inclusive extension methods to be tested for scaling out the dairy extension program.	Australian Planning Meeting leading to project implementation plan for the project	2010	Prepared implementation plans for collaborating with Livestock Departments and University staff. This involved Livestock Department's management and District Livestock Officers of proposed project districts. Risk around high-turnover of Livestock Department management staff continued to challenge the continuity of the extension program. However, field staff remained consistent; leading to well-maintained engagement at the farm-level.
		Livestock Dept. district management meetings determined action plans for field extension activities involving Govt staff	Jul-Sept 2010	Prepared implementable management and field action plans for engaging and sustaining extension activities in different districts with Livestock Department personnel

		Project team successfully organized three extension worker training workshops for Baluchistan and Khyber Pakhtunkhwa extension workers using a less intensive management approach.	July 2013/2014 & 2015	To achieve the desirable goals of a successful dairy extension program without close supervision we found certain limitations. These included accessing co-operation from their department, and familiarising their extension workers with the notion of working without incentives from our program. Security issues in some working areas were also a problem.
1.3	Implement, adapt and evaluate outcomes of these less-intensive approaches.	Trained project 'farm advisors' (20 from Punjab, 10 from Sindh) on whole dairy farming system, community mobilisation and communication.	Initial training program m 3-6 (and afterwards continuous throughout)	Meeting with team and stakeholders on developing innovative ways of scaling out extension messages. Some examples include; a whole family approach, individual farm visits, practical demonstrations at the farmer's door step, problem based learning techniques, quizzes, live drama, video shows etc.) were tested to increase adoption rates.
		Extension material developed: Extension modules=10 Factsheets=25 Fodder & feed calendar	On-going from 2011-2015	Developed by the project team in collaboration with all Pakistani veterinary Universities, Livestock Department research staff, Australian partners and smallholder farmers.
		Initiation of farmer discussion groups and continuation of extensive extension using the 'whole family approach implemented for 1500 farmers.	m 3-6 and continuous throughout	To achieve the desirable goals of a successful dairy extension program without close supervision we found certain limitations when working with extension officers from the department. These included accessing co-operation from senior management in the department who frequently were changed/moved and familiarising extension workers with the notion of working without incentives from our program. Security issues in some working areas were also a problem
		Monthly reports of farmer progress/extension worker assessment and project team feedback meetings	Continuous	The project utilised a consistent 'feedback and reflect' system to maintain a continuous critical review throughout the extension program. This was to learn as a group and with the field officers so as to adapt/change approaches given opportunities and challenges that arose.
		Impact assessment survey from different farmer groups on adoption rates. Research outcomes were presented two papers at SAADC, Thailand	Nov 2013 – Feb 2014 October 2015	Completed Impact Assessment survey to compare knowledge transfer, attitudes and practices of recommendations between registered and unregistered farmers. It was helpful to show the efficacy of the project and its impact on different farmer groups.

		Extension workers from Baluchistan and Khyber Pakhtunkhwa established and organized farmer meetings without direct involvement of dairy team	July 2013-2015	The 10 KPK & 10 Baluchistani extension staff trained by the project team returned to their own working districts and without additional input from the team implemented a 'less intensive' extension program in both KPK and Balochistan.
		Website launched and social media page established to broadcast/share appropriate information	2012-2016	Project extension material, links to useful websites and discussion papers/topics regarding dairying in Pakistan/Asia. The social media following is vibrant and has many followers from veterinary Universities across Pakistan. These links are generally former students who are now working in the industry that were involved in the project as part of our student forums.
		Dairy project final forum	October 2015	Effective dissemination of project activities, outcomes and impacts of the project to key stakeholders
1.4	Disseminate and promote the VBSE operations to other regions	Engagement with farmer discussion groups and production of 'Agronomy Module' to help grow more quality fodders for a lower cost	Sept 2014	This is now incorporated in the general extension program of the project. Project staff, extension workers and farmers have all been involved in this process. The farmer discussion groups around fodder production were some of the most engaging run within the whole program
		Farmers trialling the VBSE operation of berseem	Feb 2015	An impact assessment review of the pilot VBSE operations showed that improved agronomic practices were adopted by the smallholder dairy farmers after VBSE trials were conducted Results from the berseem VBSE farmers have shown that there was about a 37% increase in forage yield and an 82% increase in seed yields.
		VBSE operation expanded to include other fodder species (maize/millet/oats)	2015-2016	Pilot trials of other improved fodder varieties were expanded tested in all the project districts. Six maize and five millet were cultivated (summer season).
		Replicated and expanded successful pilot project of VBSE to 15 to 20 villages in Punjab and Sindh.	2014-2015	Examples from the 2014-2015 winter season have shown that farmers producing seed from the VBSE plots can receive up to 500-550 Rs/kg for their Berseem seed as opposed to the normal local seed price of 300 Rs/kg.

Objective 2: To develop and promote strategies for optimizing feed resources for smallholder dairy farmers.

no.	activity	outputs/ milestones	completion date	comments
2.1	To develop and promote strategies for optimizing feed resources for smallholder dairy farmers.	Brainstorming/planning meeting of "Nutrition Focus Group" occurred and recommended a number of initiatives and research trials including; (1) calf rearing trials, (2) fodder seed markets, (3) develop extension material on fodder production and feed formation	2011	A key recommendation of the external project review (April 2015) was that the project team would benefit from developing a more strategic approach in regards to selecting research priorities on Nutrition. This should result in a document outlining strategy and implementation plan. Using this group concurrently with a steering committee would help to realign research needs and opportunities every 12 months.
		Review of current status of dairy nutrition research in Pakistan	2011-2015	Various topics had been covered and reviewed in the development of research experiments including calf rearing feeding practices and fodder production. These reviews are reported within the publication outputs of the trials.
		Developed fodder and feed calendar for the farmers. Distributed them within the extension program.	2011	The fodder & feed calendar was translated into the Sindhi language incorporating differences in practices/varieties relating to geographical location (March 2014).
		Developed booklets on ration formulation and improved agronomic practices for the farmers	2013 and 2015	
		Training on ration formulation software by Dr Gaye Krebs (CSU, Nutrition expert) with a basic ration formulation software	May 2013	This was targeted at researchers and young professionals. Follow-up from this involved presenting the ration formulation module to extension workers and farmers in the extension program.
2.2	Based on these priorities conduct on-station and on-farm research.	Research trials (fodder and calf based) were completed at UVAS, UAF and SAU, Tandojam.	2011 - 2015	Research outcomes (particularly around calf rearing and agronomy) were integrated within the extension program.
		Two research papers produced by Dr Shaukat Bhatti are under journal review. Two Masters and a PhD student have completed their degrees incorporating this research work into their theses	2013 and 2015	Publications have been either accepted or submitted to international journals. A list of these publications is will be provided. The results from these experiments feed into the Team's extension program in the form of recommendations/success stories to share with farmers.

		Numerous farmers have tested and trialled nutrition related extension recommendations. Most widely tested and adopted are; (1) improved fodder agronomy, (2) better calf feeding strategies and (3) utilising good quality fodder seed	Throughout project. Impact assessment carried out in early 2014	Adoption of improved practices on farm and effect throughout nearby farms. Registered farmers had an adoption rate of over 95% for improved calf rearing.
		Thirteen fodder demonstration plots were cultivated with the help of private seed companies Jallundur Seeds and Pioneer seeds. These were within each of the project's focus districts in Punjab and Sindh	2012-2015	These demonstration plots have been a useful comparison for farmers to see.
		Comparison study completed between research, market and farmer varieties and best variety identified		The improved seed variety was: (1) For seed production; 4 times higher than the local farmer seed and 3 times higher than the local market seed. (2) For fresh Berseem fodder: 40% higher than local farmer seed and approx 10% higher than local market seed.
2.3	Promote entrepreneurial activity for feed resource management at the village level.	High adoption rates (>90%) relating to calf rearing and feeding. A number of farmers now see this as a viable enterprise to invest in.	2013 onwards	This was linked with the extension program and two project lead initiatives. (1) A healthy calf rearing competition targeted at children. (2) a Masters' student's trial on-farm which allowed farmers to see the calves in the treatment group showing higher growth rates.
		Developed a pilot fodder seed production system	2013 onwards	Mr ShoibTufail completed his trial on commercial scale fodder seed production systems focusing on berseem clover with farmers of Kasur and Okara districts in collaboration with ICARDA. A second round of trials was conducted that showed significant results in quality forage and seed production at the village level. Five seed entrepreneurs were also trained on improved seed production technology.

2.4	Establishing village-based forage seed enterprises (VBFSE)	Established commercial fodder seed production models in seven districts of Punjab and Sindh. Village based seed enterprises were tested in both the summer and winter seasons. Sixteen seed entrepreneurs are working successfully.	Started in 2013 and On going	This is the significant achievement of this project which established a commercially viable fodder seed production model at the village level which was readily accepted in the rural communities of smallholder farmers. This is both profitable and sustainable for these producers.
2.5	Calibration of NIR equipment to allow for ease of nutrition analysis	Sample collection completed.	2015	NIR calibration not yet completed. Due to be completed by research collaborators in mid-2016.
2.6	Replication of VBSE and promote benefits to other farmers	VBSE system was tested and trialled in all districts of the project with two seasons of berseem, and one summer season using maize and millet.	2014-2015	The success of PhD research by Shoaib Tufail has led to an increase in demand for quality fodder seed. Farmers are now seeking quality fodder seed from VBSE farmers or other sources to implement themselves.
2.7	Economic analysis of the VBSE system	Shoaib Tufail has completed a basic economic analysis from the results of his research. He found that fodder seed production with improved varieties (including the profit from fresh fodder) can be 4 times more profitable than the majority of cash crops.	2015	Solid assessment of the VBSE will be available making it clear to possible farmers (or investors) to initiate their own operations. Was tested as part of Shoaib's PhD research. The result was that 3 cuts of fodder and then leaving the crop to grow for fodder seed production was the most economically beneficial to the farmer.

Objective 3: To identify and promote profitable strategies for calf rearing.

no.	activity	outputs/ milestones	completion date	comments
3.1	Document the constraints and opportunities for rearing of both female and male calves.	Four publications (including literature review) have been completed following on station research.	2011 – 2015	Literature reviews were included within the two Masters thesis and the four publications that are being published out of this work.

<p>3.2</p>	<p>Define cost effective feeding strategies for calves.</p>	<p>Research experiments were implemented at the institution level to test a number of feeding regimes. Trials completed: (1) Effect of weaning age and milk feeding level on pre and post-weaning growth performance of Sahiwal calves (2) Effect of weaning age and milk feeding level on growth performance of Nili-Ravi buffalo calves up to age of 16 week (3) Sindh calf rearing trial; comparing buffalo calves reared from birth to weaning on buffalo milk VS cow milk (4) Buffalo Trial assessing passive immunity transfer in animals purchased from the local market.</p>	<p>Mar-May 2012. Sept-Nov 2013. Feb-April 2014. April 2015</p>	<p>These trials were aimed at providing a profitable model for dairy farmers and always involved assessing the economic components of the feeding regimens. Two papers completed and submitted to international journals on calf rearing practices in Pakistan. Papers from the two remaining trials continue to be worked on for publication. Two Masters students completed their research trials as part of Dr Bhatti's trials at UAF. The results of their work are documented in their theses. Results of the calf trial at SAU suggested that buffalo calves can be successfully reared with cow milk supporting a profitable growth rate. This has provided an opportunity for smallholder farmers to market buffalo milk at higher prices rather than feeding it to calves. 'Save the Calf Seminar" was organized at SAU after the successful completion of Kundi buffalo calf trial.</p>
<p>3.2</p>		<p>Developed on farm business plans from proven and applicable research Calf rearing practices were trialled in a number of ways on-farm.</p>	<p>Sep 2014 Feb 2015 March 2014</p>	<p>One young farmer from the district Okara purchased newly born calves from market raised on local milk replacer. This farmer then sold the milk of his own buffaloes at a higher price. He has successfully run this small entrepreneurship model in his village The price of buffalo milk is significantly higher compared (Rs 65) to the cow milk (Rs 35). Keeping in view the research findings of our Kundi Buffalo calves rearing trial. A number of farmers who witnessed part of this experiment have raised their own buffalo calves on cheaper cow milk and sold their buffalo milk at a higher rate. By increasing the intake of concentrate from a few grams per day in the first 2 weeks to one kg at weaning as milk offered decreases, the age that puberty has been attained has been decreased to 18 months. This saves farmers time, labour and resources.</p>

3.3	Implement and demonstrate a profitable business model for the rearing of both female and male calves	Based on the project's research findings a high proportion (>80%) of farmers adopted the project's general calf rearing recommendations. Farmers (~10% of all those registered) with a more entrepreneurial mind set have adopted cost effective feed strategies on their farms.	Throughout extension program. Calf rearing uptake increased from 2013 onwards.	As there has been an increase in demand for beef, farmers have been investing more time and money into male calves with better husbandry and basic feeding practices.
		A calf rearing competition was run in a number of villages to see what growth rates can be achieved under village conditions. A calf-rearing competition by children in a group of villages. This showed that children could successfully rear calves and reach weight gains that are not achieved on research stations.	February 2012	<p>The objective was to practically demonstrate profitable new calf rearing practices to both local farmers and professionals in the industry. Participants from the University, Livestock Department, different National and International organizations appreciated the results of the trial.</p> <p>This calf rearing competition played a key role in extending improved calf rearing practices in the area. Up to 70% of farmers have adopted these messages for use on their own farms</p>
3.3		Create opportunities and links for calf purchases and on-selling		<p>In a small number of villages we linked farmers with specific buyers/middlemen. However, long-term relationships need to be developed between farmers and calf buyers as beef farming value chains develop to support this relationship.</p> <p>In a 2 – 3 targeted villages a 'girth tape' was introduced to gauge the live weight of the calves to assist with the accurate pricing of the calf. The procedure gave farmers more confidence in negotiations of prices received from the middleman.</p>
3.4	Publicise commercial opportunities for calf rearing at the farm level	Develop and publish recommendations for commercial opportunities	Throughout.	<p>Publications accepted from 2012 and others currently under review.</p> <p>Calf rearing extension module publicises the benefits of improved feeding/management for better sales opportunities. However, lack of beef market knowledge limits their options for sale.</p> <p>This module has been translated into the Sindhi language and disseminated to the farmers of Thatta & Badin. This module is highly appreciated by the farmers and extension workers of Sindh.</p>

		Involve departmental staff in dissemination of recommendations 'Save the calf seminar' Sindh Final Forum	April 2014 October 2015	The recommendations/success from this research was shared with the project extension workers (Livestock Dept.) and communicated to all the farmers within our project. This success has also been shared with university and Departmental staff.
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Objective 4: To identify and promote strategies for improving smallholder profitability through marketing opportunities of a higher quality product.

no.	activity	outputs/ milestones	completion date	comments
4.1	Identify economic and policy constraints for profitable small holder dairy farming	Review of dairy policy on both a regional, national and provincial level	Research 2012-2014.	This involved a review of the literature available on the topic as well as the research carried out by two PhD students (Sosheel Solomon on milk markets & Naveed Aslam on milk quality). The findings of their reviews are embedded within their PhD theses. These are currently being composed into journal publications. Results were presented at the Annual Conference of the Australian Agricultural & Resource Economics Society, (7-10 February 2012), Fremantle.
		Develop recommendations for policy needs within the government	Two theses completed in 2015.	Recommendations relating to policy are incorporated within these two theses (summaries can be seen in the 'Results' section of this report). They have also been shared with the ASLP Policy Project, which is currently putting together their conclusions for the project, which will be shared with the relevant partners. Naveed has also published two research papers from this work (details in reference list).
		Map of the economic value chain of milk production and sales	2015	This is included within Sosheel's PhD thesis. Journal publications from this work are under construction.
4.2	Conduct an evaluation of milk marketing chains in Pakistan	Involve Australian and Pakistani expertise in a value chain analysis of Pakistan as well as a comparative and successful model from elsewhere	2012-2013	Value chain mapping and assessment carried out in collaboration with CSU experts (Dr Gavin Ramsay, Dr Karl Behrendt), and NSW DPI (Dr Tom Nordblom) as a supervisory team. This also included input from ASLP Mango-Supply Chain Team (Dr Ray Collins and Dr Tony Dunne). Three rural-urban fresh unpackaged milk value chains from three dairy project districts in Punjab were studied. This is the first time a detailed in-depth study of these traditional chains has been carried out.

4.3	Define and implement interventions that add value or improve efficiency of the milk value chain	The completion of a consultancy report outlining marketing options for smallholder dairy farmers	Not formally completed	A consultant was enlisted to do this work, but at the time for various reasons the work could not move ahead. Instead the project with the help of Sosheel's PhD research addressed this issue by coming up with an extension module on marketing and milk value addition. This included options for smallholders to increase their income by engaging with different marketing options.
		Recommendations for farm advisors and project staff to run effective marketing interventions with smallholder dairy farmers across Punjab/Sindh	2014-2015 within Extension Program	This project has provided increased marketing options for smallholders and increased profitability for the milk produced. These options are based on shortening the value chain and supplying milk more directly to the consumer.

Objective 5: To build the capacity of future and current extension and industry personnel driving the production and marketing of milk from the farm to the consumer.

no.	activity	outputs/ milestones	completion date	comments
5.1	Improve the effectiveness of milk extension staff of collaborating organisations	Development of "Dairy Farm Advisor Training" curriculum	On-going exercise carried since 2011	Developed extension material; 10 modules and 25 Farmer fact sheets presented. Topics covered are outlined in the 'Methodology' section of this report.
		Implementation of training to field staff by suitable training institute/s and the project team	An on-going exercise carried out every 3-4 months since 2011	Organised ten extension worker training workshops on whole farming system (presenting the extension material developed).
5.2	Provide opportunities for future leaders of the Pakistan dairy industry through short term strategic training	Complete short-term training for young scientists from Pakistan	Jan/Feb 2011 & Jan/Feb 2012 On-going July 2013	Student forums with students from all over Pakistan were carried out in 2011 and 2012. The internship program is ongoing and the project has trained young veterinary and agronomy students (approx 30 in total) from 3 different universities. ICMJ Meat Judging competition and visit to Australia organised for 5 young meat scientists from Pakistan.
		Sponsor short-term academic courses	i. Feb 2014 ii. April 2014 iii. Throughout iv. November 2014 v. September 2014	Our project team and various other students/researchers have been involved in these activities. Including: i. Communication/media training ii. Impact assessment ii. Conferences overseas (Thailand/Australia/Indonesia/China) v. ACIAR Workshops (Indonesia) v. Writing workshops in Australia

5.3	Promote linkages between Pakistani and Australian students and scientists for the mutual benefit of both their livestock sectors	Strengthen the linkages between Pakistani and Australian experts by completing collaborative review publications	Throughout	Numerous publications completed with authors from both Pakistan and Australia. Other linkages provided by running seminars/workshops on different topics; (1) Breeding & Genetics workshop on Sahiwal cattle (Oct 2014), (2) Statistics workshop (October 2014), (3) Feed formulation (April, 2013), (4) Fodder growth/production (Jan 2012).
		Conduct Australia student visits to Pakistan and be involved in a Student Forum	2011 & 2012	Completed. Two were carried out in 2011 and 2012. Other CSU student trips were planned for 2014 and 2015 but were cancelled due to security protocols and concerns.
		A number of awards/ scholarships awarded to project team members	2014/2015	Shumaila Arif (2014), Sajid Latif (2015) and Zahra Batool (2016) have been awarded a John Allwright Fellowships for their post graduate studies in Australia. Yasir Nawaz awarded a Fullbright Scholarship to study in the USA (2015). Azher Bhatti awarded a scholarship from the Norwegian Govt to study his Masters in Norway (2014) Hassan Warriach awarded a John Dillon Fellowship (2014).
5.4	Training extension workers in VBSE operations	Training workshop on VBSE operations and benefits	November 2014 Winter season 2014-15 & 15/16, Summer season 2015	Capacity building workshop (3 days) completed within Dairy Extension model. Demonstration plots run at project sites with Livestock Department Extension workers and local villagers.
		Dissemination of this information to the extension workers farming communities	2014/2015	This is now incorporated into the extension model with a module on agronomy and fodder production.

7 Key results and discussion

Extension model

Extension material

One of the major strengths of the project was the development of quality extension material. The project has developed a complete package of extension material (10 modules, 25 fact sheets and 'Fodder & Feed Calendar') covering the whole smallholder dairy farming system (available on request). The messages included in the extension material are simple, adoptable and impact oriented. This extension material is a valuable source of knowledge and skills for the target audiences (both farmers and extension workers). The main attribute of this extension material is to focus on the issues related to farm productivity for smallholder dairy farmers, with the objective of increasing profitability and improving the livelihoods of each household.

Farmer Adoption

The effectiveness of our extension material was gauged by the level of knowledge, understanding and practice adoption rates of on-farm recommendations. This impact study looked at recommendations from seven of the project's extension modules. Within each module there are 10 - 20 recommendations and it would be challenging to properly capture understanding and adoption rates from each message (over 300 messages in total). Instead, one key message was chosen from each of the seven modules; this message had to be applicable, sustainable and have an impact on-farm. During the impact study, farmers were asked questions that assessed their level of knowledge and understanding of each of these seven messages.

The team assessed the effectiveness of extension through a survey of three types of farmer participants: registered farmers ($n=179$, direct beneficiaries receiving intensive support on a monthly basis), unregistered farmers ($n=116$, indirect beneficiaries, neighbours/friends within the community), and traditional farmers ($n=106$; control group, no link to the project's extension program). This research showed that the biggest impact (in terms of higher adoption rates) was achieved with registered farmers. However, a positive result which highlighted the flow-on effect of the extension program was that the unregistered farmers also experienced significant impacts which were higher than those observed with traditional farmers): importantly this response was achieved at a lower extension cost (Figure 3).

Only four out of the seven messages assessed in the study are presented in Figure 3. The adoption rates of registered farmers for these extension messages is as high as 95% for simpler messages, which have little capital input required. However, the range in adoption is from 40-70% for most recommendations, as capital expenditure is required in some cases. For example, the extension message on free access of water through untying the animals has been adopted by 40% farmers, which resulted in a 25% increase in milk production per animal per day and an enhancement of income of up to PKR 9,500 per month (approximately AUD 125). The major constraint to adopting this message, according to non-complying farmers, was the high input cost.

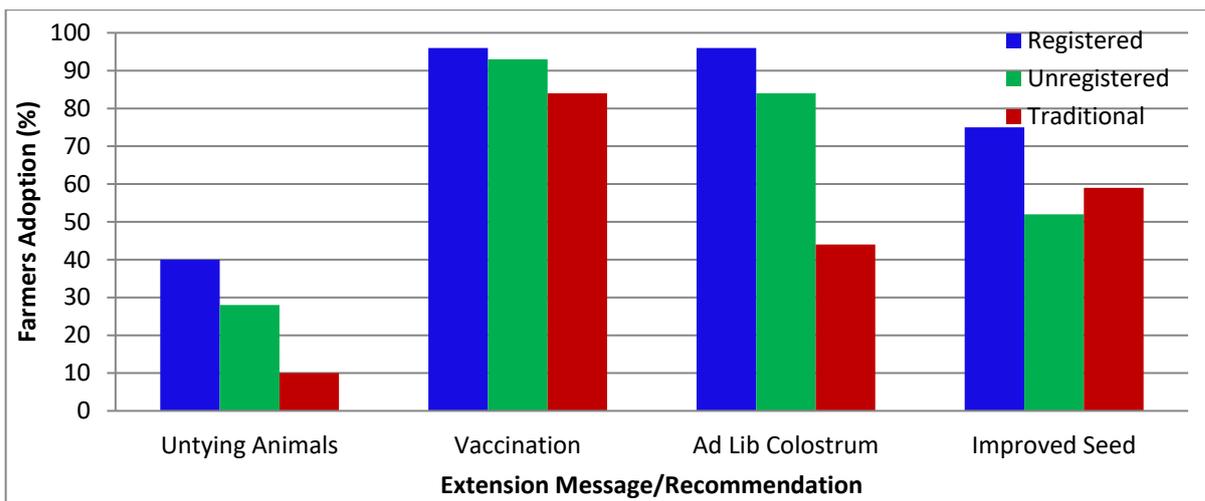


Figure 3: Adoption rates of four important extension messages by registered, unregistered and traditional farmers (*Total number surveyed, 399 across both Punjab and Sindh*).

In contrast, the adoption rate of extension messages on vaccination and deworming is significantly higher in registered (96%), unregistered (93%) and traditional (84%) farmers. This suggests two things; (1) that farmers are more willing to adopt practices which have a lower input cost and (2) that farmers were already well aware of this practice, due to this topic being the main focus of the LDDD farmer engagement program.

Arguably, the extension message that might lead to the greatest impact is the one relating to calf rearing and colostrum. Looking at the plot in Figure 1, the differences in adoption rates between the registered farmers (96%) and unregistered farmers (84%) compared with the traditional farmers (44%) was larger than for any other message. This shows that the information on calf rearing and feeding was both novel and highly adoptable. This is an important result as it illustrates the flow-on effect of the project to unregistered farmers. This also highlights the importance of determining the ‘gaps’ in farmer knowledge so that applied research can be used to address them and then supply ‘new’ information back to the farming groups. This ‘new’ information will create interest among the groups, which will enhance the engagement with the farming groups as well.

We attributed the higher adoption rates achieved in ASLP-2 to the development of our whole-family approach to extension with no incentives offered. Although a direct comparison is difficult to make, adoption rates from the ASLP-1 project for providing free-access to water, for example were about half of that within the second phase. Thus our levels of success with 1,500 registered and 3,000 unregistered farmers were quite significant.

Nutrition Initiatives

Nutrition Focus Group

The project incorporated a “Nutrition Focus Group” (NFG) in order to devise appropriate strategies for optimizing the feed resources of smallholder farmers. The group included top experts from national and international research institutions and the private sector. They developed a ‘Fodder & Feed’ calendar and a ‘Ration Formulation Booklet’. An ‘Agronomy module’ was also developed to facilitate the farmers as well as extension workers. With each of these training materials, farmers were technically guided with a

package of best management practices for growing fodder, planning feed availability throughout the year and formulating balanced diets for their animals.

These materials became important sections of the extension program and were extremely popular with both farmers, extension staff and researchers. The 'Fodder & Feed Calendar' has been utilised and adapted by a number of other organisations including Nestle Pakistan, who have produced printed copies for their own farm extension arm and Sindh Agricultural University Tando Jam, who have translated and produced copies for both farmers and students. These materials are proving to be popular with extension staff and researchers in providing nutritional advice to farmers leading to much more informed decisions being made about feeding animals.

Village Based Seed Enterprises

In Pakistan, over 150 million livestock, including cattle, buffalo, sheep and goats, require a year-round supply of green fodder. The production capacity of existing infrastructure for quality forage seed is a major limiting factor for fodder production. This gap is exacerbated by the importance that farmers place on animal ownership, with animal numbers exceeding the capacity that farmers have at their disposal to produce fodder to feed them. Berseem clover was chosen as the target fodder as it is the major rabi or winter source of forage. Clearly the provision of berseem seed capable of higher forage yields would assist in alleviating seasonal feed shortages. Village based seed enterprises (VBSE) have been developed to provide sources of high quality seed to farmers in the same district that the enterprise is located. Thus local farmers who are engaged in this activity are able to profit from the sale of superior quality seed and at the same time harvest forage to feed to their own animals with any excess sold to neighbouring farmers. The only inputs required are a supply of high quality seed from research stations and technical advice on how to maximise forage and seed production.

Production: The outcomes of this research was that by using a village based seed enterprise model, participating smallholder farmers increased their fodder seed production by 211% (with an average of 580 kg/ha), fodder yield by up to 39% and DM yield by up to 46% compared to farmer seed. Additionally, improved variety seed also produced quality fodder with 3% more CP and 2.5% more DMD with 5% less fibre contents.

Marketing: The VBSE farmers now sell Berseem clover seed to village farmers at the rate of PKR 450 per kg, which is premium price compared to market rate of PKR.283 per kg for an inferior product. The higher price readily paid by farmers for the superior seed reflects their recognition that feed retained over the years by them from their own crops is of poor quality. VBSE are now considered as sustainable enterprises, with individual farmer case studies in which participants produced an average of 580kg/ha (with some case studies showing production up to 815kg of seed/ha).

Profitability: The main emphasis of the establishment of VBSE was in improving farmers' ability to assess the profits of their enterprises and ultimately improve their whole farm productivity and profitability by producing and selling high quality seed. Financial analysis of enterprises adopting the improved agronomic practices of growing Berseem forage and VBSE technology, showed that average net incomes of PKR 512,340 per hectare were achieved (based on predicted seed yield). This is 4 times higher than they earn from any other cash crop grown in the region. The partial budget analysis of VBSE farms further

revealed that the average benefit:cost ratio was recorded 5.3:1 with marginal rates of return of 432%. This is well above the minimum benchmark of 40-100%² for farmers adopting a new technology on farm after accounted for capital cost, risk and inflation rate in Pakistan.

Calf Rearing Research

In Pakistan high calf mortality rates (50 %)³ and poor growth rates (60-80 g/day)⁴ are among the major limiting factors resulting into low economic returns to the farmers. Little to no information on basic calf care and husbandry is available for dissemination to farmers from any source.

The project took initiatives to address this lack of research and to identify and promote profitable calf rearing strategies. The project conducted a series of calf trials on indigenous dairy breeds at different Universities and research institutions across the country (see specific results outlined below). Overall the results of these trials clearly demonstrated that we can reduce the mortality rate⁵ to less than 5% and enhance growth rate⁵ up to 400 g/day during pre-weaning period. The outcomes of these research trials have been transformed into simple and adoptable extension. Key messages like feeding *ad libitum* colostrum immediately after birth has resulted in a significant reduction in calf mortality. All of these messages have been disseminated to farmers, extension workers and academia as part of the project's extension program.

Detail of experimental results:

Experiments carried out at the University of Agriculture Faisalabad:

Collaboration with the Buffalo Research Institute: An experiment was carried out with the objective of evaluating the growth performance of early or late weaned *Nili-Ravi* buffalo calves offered varying milk volumes. The results show that the highest average daily gain from birth to 16 weeks was recorded in high milk (fed 15% body weight in milk per day) late weaned (12 weeks) calves and poorest in low milk (fed 10% body weight in milk) early weaned (8 weeks) calves (546±25 g/day vs 321±25 g/day). While early weaning or low milk volumes minimized the feeding costs, these resulted in lower body weights and average daily gains. Choices of pre-weaning feeding regimen should be made keeping in view both feeding cost and performance of replacement calves. The results of this study suggest that weaning at an age of 8 weeks and feeding milk at a rate of 15% body weight per day is more economical than feeding at a rate of 10% body weight.

Collaboration with the Livestock Production Research Institute: A similar study investigating feeding regimes and the effect on pre and post-weaning growth of Sahiwal calves found that high milk feeding (15% BW/day) or late weaning (12 weeks) of Sahiwal

² Shah, H., Hussain, K., Akhtar, W., Sharif, M. & Majid, A. 2011. Returns from agricultural interventions under changing price scenario: A case of gypsum application for moisture conservation for wheat production under rainfed conditions in Pakistan. *World Applied Sciences Journal*, 14, 363-368

³ T. Zaman, 2006, *Pakistan Veterinary Journal* (page 121-125)

⁴ Younas et al, 2002, *Rural Livestock production in Pakistan*, Report by UAF, Faisalabad

⁵ Bhatti et al, 2012, *Tropical Animal Health and Production* (page 819-826)

calves resulted in higher live body weight at 16 weeks. This regime, however, was the most costly. Low milk (10% BW/day) feeding and early weaning (8 weeks) was the cheapest, but resulted in the lowest BW at 16 weeks of age. High milk, early weaned and low milk, late weaned calves achieved a comparable BW. Although these calves were smaller than high milk late weaned calves, the liveweight gain was achieved more cost effectively. The conclusion of this study was that high milk intake, and early weaning saved on milk and labour costs. It appeared to be the best method of raising Sahiwal calves and could be more cost effective during the pre-weaning period.

Experiment at Sindh Agriculture University, Tando Jam

“Save the Calf” – the story of a calf trial in Sindh

The project conducted its first research trial on Kundhi buffalo calves at Sindh Agriculture University, Tandojam in early 2014. The main objective of this trial was to demonstrate cost effective calf rearing strategies to all stakeholders. Calves were procured from a peri-urban buffalo colony where farmers have never practiced calf rearing due to the high feeding cost. They have traditionally sold them to butchers for slaughter on day one of life. A team of project staff, interns and research students successfully reared these calves utilizing the University facilities with an average growth rate⁴ of 350g/day (in the first four months) which is three fold higher than achieved in commercial practice. Subsequently, these calves were sold in the open market with a profit margin of 30%⁶. At the completion of the experiment, the project organized a “Save the Calf” seminar where results and their implications were shared with farmers and other stakeholders. Now many farmers from peri-urban dairies are retaining their young calves for their future herds.



Photographs: (1) Sajid Latif (project staff) and a Sindh Agricultural University Masters student weighing a Kundi Buffalo calf and (2) Participants engaging with the ‘Save the Calf Seminar’ at Sindh Agricultural University Tando Jam.

Experiment out at University of Veterinary and Animal Sciences, Lahore:

Rearing buffalo calves purchased from the local market. The experiment ran from March 2015 to August 2015. Outcomes from this research highlighted that animals obtained from the local market are extremely variable in quality and health status: in effect the husbandry practices used during the colostrum feeding period on the first day and the

⁶ Majeed, S. et. al. (2017). Cost effectiveness and effect of buffalo and cow milk feeding on growth performance of pre-weaned buffalo calves. SAADC, Indonesia.

amount of milk offered subsequently cannot be predicted. Purchasing these animals and feeding them supplements and substitutes for 'colostrum' to make up for these shortcomings is not a viable option for farmers. The project concluded that, promoting a profitable calf rearing strategy for farmers must start at birth to ensure the feeding of the correct volume of high quality colostrum is adopted.

Milk Marketing

In Pakistan the smallholder dairy farmers contribute about 95% of the milk produced yet many of these small dairy enterprises are not profitable. The poor milk marketing system leads to a low profit margin to the producers, and consumers are paying a high price for low quality milk. There is a need to develop and implement uniform milk quality standards and re-regulate the pricing mechanism across the country.

The project has investigated a diverse range of milk value addition and profitable milk marketing strategies in which both male and female members of the farming family can be engaged. After adopting these individual and group marketing strategies, many farmers working with the project have turned their dairy enterprise into a profitable business. The direct marketing of milk from the farmer to the consumer and cutting out the middleman, for example, has increased the profit margin for one farmer in Jhelum by 25%.

Another example where change in marketing strategy has been effective in increasing profit was with a group of farmers in village Kot Hukam Singh (Pakpattan). They initially made the change from using traditional marketing chains to a private dairy processor resulting in an increased profits margin of 10%. With the help of the project they decided to open a community milk shop in their neighbouring city resulting in a further 40% increase in profit margin.

Women farmers have adopted different options to maximize their profit margin including the manufacture of ice cream, ghee, khoya and cheese and flavoured yoghurt as well as separating and selling cream. All these strategies double the value of milk in the marketplace. In the future there is a need to expand these entrepreneurial activities with farmers working co-operatively to link with markets/medium sized processors to negotiate higher prices for better quality milk. These recommendations cannot be fulfilled without adjusting government pricing policies to facilitate a free marketing environment.

Analysis of traditional marketing chains

This analysis was carried out by Sosheel Solomon and provided the basis for his PhD thesis. Although 95% of all milk marketed in Pakistan is sold through traditional milk marketing chains, these have been seldom studied in any detail. The need to undertake this investigation arose from the financial analysis of some of the smallholder farmers enrolled in the ASLP-1 program owning 6 or less animals. It was clear that even the most efficient farmers were losing money for every litre of milk they produced. But of course farmers keep animals for more reasons than to simply make money from the sale of milk. The ownership of animals acts as a family "bank"; they provide social status as well as a mechanism for payment of medical expenses and dowries and funerals.

Analysis of 3 traditional chains soon showed that they were rife with malpractice through the use of non-standardized volume measuring containers designed to "maximize" the profits of milk collectors and vendors. At the same time the milk was adulterated to increase volume as well as fat and protein content. Yet the chains were held together through a series of loans that pass from the largest milk distributor back to the farmer to

pay for feed and medicines and forward to the shop owner to pay shop rent. Thus extension activities with these chain operators was seen to be extremely challenging, since change of practices might well take a lot of middlemen out of business.

Clearly there is a need to connect the producer more directly with the consumer to ensure that the farmer is rewarded with a higher price for quality milk and at the same time the consumer benefits from receiving a high quality product.

The project's dairy extension activities on marketing, outlined above, have evolved from these results **which are published in Sosheel's PhD thesis.**

Mycotoxins and milk quality

This research was carried out by Naveed Aslam and provided the basis for his PhD thesis. Mycotoxins are increasingly prevalent in products passing down the human food chain, with adverse consequences for the health status of the consuming population. These toxins come from fungi that proliferate in poorly stored food for humans and feed for livestock. One class of mycotoxins, the aflatoxins, have been found in dairy products in Pakistan at levels that exceed by 50-fold the international standards for their content in milk and milk products.

In spite of the importance of the buffalo to the milk supply of Pakistan there are no published data on the metabolism of aflatoxins in buffalo. Analysis of commercial sources of cottonseed feeds and corn gluten, both used liberally as concentrate feeds for dairy production, showed that they were potent sources of these toxins. In studies with lactating buffalo, around 5% of ingested aflatoxin B1 was metabolized and passed directly into milk as Aflatoxin M1. Around 15% of the toxin was excreted in urine. Importantly the removal of contaminated feed from the feedbase for buffalo results in a precipitous decrease in milk toxin concentrations within a few days.

The project has led to recommendations to animal feed companies to analyze all products they sell to farmers to ensure that no mycotoxin can pass through to milk thereby compromising the health of the consumer. These toxins also disrupt the reproductive cycle of the buffalo, thereby exacerbating the problem of seasonal anoestrus in buffalo observed over the summer period.

The project also showed that 15% of milk samples collected from retail outlets contained unacceptably high levels of antibiotic residues, which again will have adverse consequences for the national health bill for Pakistan.

Capacity Building

The capacity building component of the project has made a substantial contribution in the generation of trained man power in the form of team, students, researchers and extension workers. Details of the major components of the capacity building within the project are outlined below.

Extension worker training

The project has organized a series of training workshops for the capacity building of extension workers of the Livestock Departments from all the provinces of Pakistan.

A paper currently in being finalized looks at the "Impact of training on knowledge, communication skills and self-assessment of dairy extension workers".

The objective of this study was to assess the efficacy of technical training conducted by the project on field extension workers (n=26) in terms of their level of technical knowledge, communication skills and levels of self-confidence. Each of these measures were compared between the control extension (n=26) staff and those that underwent our training. Further comparisons were made between extension workers who were veterinary officers (VO) and veterinary assistants (VA) as well as extension workers who were from either Sindh or Punjab province.

Knowledge level: The results indicated that the level of technical knowledge of trained staff was significantly higher ($p < 0.001$) than the untrained controls. It was also observed that VOs were not significantly different ($p = 0.261$) from VAs and extension workers from Sindh exhibited a significantly lower ($p\text{-val} = 0.004$) knowledge level than extension workers from Punjab. A comparison of the knowledge scores of the trained and control staff suggested that the trainings led to a greater improvement in the knowledge level of VAs than VOs. This means that in the short-term VOs are more likely to be capable extension officers, but if appropriate training and time is allocated, then VAs can perform at the same level of capability. This has implications on the human resources as, although VOs are present throughout most districts of Pakistan, there are many more VAs that could potentially play a role in any extension program.

Communication skills: Communication skills of trained staff were significantly better ($p < 0.002$) than the control staff, however there was no significant difference between VO's and VA's. The absolute difference between the trained and control group within the VAs and VOs was the same, suggesting that the capacity building support provided by the project had the same effect on the communication skills of both groups.

Self-assessment: Based on their own assessment of their ability to carry out the main tasks of an extension worker with confidence, the perceptions of trained staff were significantly higher ($p = 0.013$) than the controls.

Engaging early career scientists

Internship program: This program has been rated as one of the top choices among students across the country due its multidisciplinary training approaches and long term career development opportunities. Thirty students from leading universities of Pakistan have been trained within this program.

Postgraduate Students: The project's approach of involving post-graduate students on research into applied issues affecting smallholder farmers remained a highly successful component of our project. There are more than 30 such students who have completed their research work under our guidance and outcomes of their research have been incorporated in our extension material and published in high impact factor journals.

International Exposure: The project has organized four trainings in Australia to provide international exposure for young professionals from the dairy and meat industries of Pakistan. Project team members have also presented their research work in more than twenty five national and international conferences.

The project also conducted three student forums involving Australian and Pakistani students from all twelve Veterinary schools across the country. This created a positive environment for students to interact and learn from the experiences of their counterparts from different countries and regions within them.

Awards/Scholarships: Furthermore, six prestigious post graduate scholarships and two fellowships have been awarded to team members which reflected the international recognition of the project.

Field training: The calf rearing trials of the project have been successful in motivating 'calf research' at various Universities which are now carrying out similar research without financial support from the project. Throughout these trials, more than twenty five students from different institutions have acquired on-farm practical training on calf rearing. This has never happened before and now this skilled human resource is serving the future of Pakistan's dairy industry.

Scale out

The extension model developed by the project was expanded to KPK, FATA and Balochistan, through three training workshops for extension workers from these areas. This less intensive approach to extension had some success in engaging extension workers and seeing an impact on farms in their provinces. However, the sustainability of this program requires a much greater buy in from their departments to ensure they are supported in this type of 'extension' which is not the mandate of their current roles.

8 Impacts

8.1 Scientific impacts – now and in 5 years

In the last five years the project has published a number of scientific papers in different journals. A list of these publications can be seen in the reference list (Section 10 of this report). Other than the already published papers, there are a number of publications under review (see list below the published papers, also in Section 10) and additionally research from the latter years of the project is nearing completion. Although some is still in the process of being submitted, the scientific impact of this research is outlined below.

Applied research culture: The project was successful in promoting a culture of applied research in several Universities of Pakistan. The dairy team conducted a series of calf rearing trials with Dr. Shaukat Bhatti at the University of Agriculture, Faisalabad as well as others at Sindh Agricultural University and UVAS. Since we commenced this collaboration 5 years ago, Dr Bhatti has managed to obtain several other grants from various national donors and private sector investors and has supervised over 20 postgraduate students. He is now acknowledged as an expert in the field and is involved in policy making committees, has published a series of research papers in impact factor journals and attended a number of national and international conferences and developed strong linkages within the industry.

Calf growth rates: Based upon our research findings under research station conditions and with smallholder farmers and in a calf rearing competition for children, we have demonstrated that calf mortality on farm can be reduced from 50 to 5% with growth rates of 250-400g/day. This is a significant improvement on the 60-80 g/day that is currently seen in field conditions in Pakistan.

Cost effective experimentation: The project has utilised novel approaches to experimentation to create a greater impact of the scientific outcomes. For example, to showcase the cost effectiveness of calf rearing the dairy team conducted a Kundi buffalo calf rearing trial at Sindh Agriculture University, Tandojam. The cost to raise one calf (to four months of age) was approximately PKR 10,000; these animals were then sold for PKR 13,000 at auction at the end of the trial. Farmers, extension workers, academics, researchers and personnel from the private sector were involved in this process to ensure appropriate rigour was used in the conduct of the trial. At the completion of this trial at least three other research groups adopted the same approach to their research.

In addition to this, one year after the completion of this trial a project team member visited the peri-urban farming community near SAU where the calves were sourced for their experiment. He observed that the results of the experiment had encouraged the farmers in this system to alter their calf rearing practices. The impact of this in 5 years' time could be substantial by bringing female calves into the production system at a much younger age and male calves with a faster growth trajectory requiring less feed to bring them to marketable liveweights for meat production. Similar impacts have been noticed in villages of Punjab and Sindh where the extension program has been implemented.

Fodder Seed Production: Outcomes of the VBSE research have shown that we can increase berseem clover fodder yield by 39% and seed production by 211%. Furthermore, the price received for this quality seed is around PKR 450 per kg which is a premium price

high quality seed when compared to the value of seed sold in commercial markets of PKR 283 per kg. These improvements in production and quality are both significant in their own right, but the scientific and farm management principles that have been elucidated by this research will be important in the development of future commercial seed production initiatives. Findings behind these values are extremely important as they highlight the capacity of local researchers and farmers to participate in cooperative action research that addresses agronomic questions. The key conclusions for maximum profitability included:

- Optimizing the number of forage cuts – three cuts for fodder, then leave for fodder seed production. This was the most profitable option leading to an increase in fodder production of 39% and seed production of 211%.
- Sowing rates/Seeding rate – 10 kg/ha seeding rate (half of the recommended rate) produced statistically similar forage yield and quality. However, 20 kg/ha seeding rate was found optimum for better seed yield (findings of research trial), which is equal to the current recommendation.
- Sowing times – 2nd week of October was found better sowing time in all the experimental trials during both the growing seasons. These findings are in line with the available literature.
- Bees/pollination – use of honey bees during pollination stage lead to double the amount of fodder seed produced (120% increase in seed yield).
- Inoculum – Its use increases green forage (26%), DM (39%) and seed (118%) yields over non-inoculation (control). Also increased nodule counts by 61% and Nitrogen (N) in the soil by 45% (Equivalent to one bag of Urea). It produced additional net income of PKR 111,913 to the farmers (both forage + seed).
- Nitrogen fertilizer – Reduced Nitrogen fertilizer use by about 1/3rd (from 75 to 20 kg N/ha) as a result of these research trials.

8.2 Capacity impacts – now and in 5 years

Livestock Department Extension Staff

Punjab and Sindh

During the last five years, ten extension worker training workshops were organized for the training of selected extension workers from the Government's Livestock Departments of Punjab and Sindh. Staff now have improved skills in a number of techniques of practice change including improved communications, increased knowledge, greater confidence and a better understanding of the decision making environment faced by farmers. This all leads to more effective extension processes as the staff work as an all-inclusive team with the farming communities

Consequently, there has been an increase in social acceptance of these extension officers. For example previously interaction with the farmer communities focussed almost entirely on curative measures to improve animal health. The process of information dissemination has now changed from being almost exclusively didactic to an approach involving extension workers spending their time with the farmers in interactive discussion groups exchanging ideas on the full spectrum of practices that sustain high levels of production and animal health. There is a major component on animal nutrition, which forms the very basis for farmers developing an understanding of preventative medicine. The establishment of trust with farmers, both male and female and then their partners and children has been the hallmark of our high extension adoption rates.

The dairy team carried out a study to demonstrate the impact of training on the Livestock Dairy extension workers. The results clearly indicated that after 3 years of regular training, the knowledge, communication skills and self-confidence was significantly higher in project-trained extension workers compared to the extension staff from the Livestock Department that were not a part of the training program. The study also showed that after 5 years working with the project, extension workers have been able to capitalise on their increased knowledge and communication skills to help them expand the client base for their own private practices.

From an organisational perspective, the Livestock Departments are starting to recognise the value in extension and communication with farmers, particularly around fodder and feed. They have recently developed an SMS platform where farmers can be contacted with feedback provided directly to the central office. This shift puts the project-trained extension workers in a unique position in which the skills that they acquired throughout the project can be applied to their present duties and then passed on to other staff in their respective departments. These staff are then able to spread these new-found skills further afield to scale out to other districts. Our impact therefore is expanded greatly across a region to influence many more farming communities.

In April, 2013 Dr Gaye Krebs from CSU trained all the extension workers on simple ration formulation software that she had prepared which included the ingredients available in the Pakistan situation. Thirty extension workers were trained and its short term impact was the development of more sophisticated formulations that accounted for the animal's age, liveweight and stage of lactation. In 2016, two to three years after the training program the majority of the extension workers still use the ration formulation software and continuously interact with farmers about utilizing alternate feeds. For example, in Bhakkar district farmers are effectively incorporating beet pulp and by-products of lentils in their cattle feeds.

KPK/FATA and Balochistan

The project has organized three training workshops (five days each) for the technical training of extension workers/veterinary officers from KPK, FATA and Baluchistan. The project's dairy extension material package was provided to each and every extension veterinary officer working in KPK province. Although not being closely monitored or supported, feedback suggested that some extension workers were effectively utilizing this material. According to the feedback provided by the extension workers, approximately 20% of veterinary officers trained were regularly conducting farmer trainings workshop; this is in addition to their normal roles within the department. For example, Dr. Akhtar Ali is veterinary officer in SWAT Valley who is pro-active in engaging with local farmers and encouraging adoption without any incentive program. He is in regular contact with the project team to seek advice on the various issues he is facing and is always looking for ways to engage farmers more effectively to achieve higher adoption rates.

Researchers

During October 2013, a biostatistics workshop was carried out for early career professional and research students. A group of 40 students from different universities attended this workshop. Assoc. Prof. Peter Thomson from The University of Sydney was the resource person for this workshop. The aim was to provide hands-on training on Genstat software for bio-statistical analysis. A large number of students continue to be associated with Peter Thomson who is providing ongoing advice on data analysis and

experimental design. Due to his outstanding contribution, the Vice Chancellor, University of Veterinary & Animal Sciences, Lahore appointed him as an Adjunct Professor at UVAS.

During September, 2014 the whole project team were given the opportunity to attend an international conference at Canberra, Australia. Hassan Warriach (Project Manager) was invited as a key note speaker, and four team members also presented their research posters in the conference. During the visit to Australia, the team was also involved in training workshops focussing on research writing and photography to help with effective communication of our research findings. As a result of these training workshops, every team member was assigned one research project which addressed a major project activity including impact assessment with farmers and extension staff, the role of women in extension, and more production related topics such as calf rearing. Six research papers are drafted and in the final stages of editing and will be submitted to both local and international journals for publication.

Student engagement

The project has provided postgraduate research opportunities for eight PhD and fourteen MSc students (outlined in section 10.2). The outcomes of the research work carried out by these students has provided valuable technical information which has been fed into the dairy extension material, thus providing a direct link between research outcomes and the smallholder farmers of Pakistan. Although some of their theses are still in the process of finalisation, these students are now well equipped to carry out successful careers in scientific research, applied extension or management. Four of the PhD students have completed their thesis; two are now employed in University academic positions (within Australia) and two are looking for post-doctoral opportunities. The other four PhD students (three of which are John Allwright Fellows) are at various stages of their research work.

A valuable component of the team's support for early career scientists is the internship program. The cohort of 35 interns engaged over the last five years have provided young trainees to enter our program or to be employed by others including the state Livestock Departments. As part of their internship program, the project provided a road map for their career development and majority of the interns obtained promising jobs, study opportunities and scholarships. Based on feedback from intern alumni, approximately 20% of the interns continued to work with the project, 60% are pursuing their postgraduate studies and the remaining 20% work for the public service or private sector (eg; Engro/Nestle). Having this internship program gave the project an opportunity to train young scientists with a systems approach to animal production with a focus on communication and positive engagement with team members, researchers and farmers. Some of the long term impacts of this internship have already been observed as the project has engaged with a number of our interns now employed by different organisations and found that the same work practices learned from the project are now employed routinely in their organisations.

8.3 Community impacts – now and in 5 years

The project worked with fifty six small holding farmer communities in a diversity of ecological zones, each with their own unique challenges for education, economic management and social engagement. The project through its improved extension as well as research based practices is having a valuable impact on the lives of these farming communities.

Project-trained extension workers (from the Livestock Departments) provided monthly training opportunities through farmer discussion groups to registered smallholder dairy farmers. The outcomes of these extensive interdisciplinary trainings challenged the mindset of the farmers and their families and encouraged adoption and adaptation of improved farm practices. Each recommendation had different impacts on farming households. Synergies between adopted recommendations were observed and farmers implementing more recommendations derived greater benefit for their farm productivity and profitability. In addition to our impact on project registered farmers, a “ripple effect” was observed in neighbouring (unregistered) farmers. These farmers demonstrated an increased awareness and capacity to change by replicating recommendations they had observed on registered farms. An outline of some of the observed impacts are detailed in the section below.

8.3.1 Economic impacts

Farmer level

Free access to feed and water through untying animals and improved farm practices showed significant improvement in animal productivity. For example, Muhammad Farooq (district Jehlum) was the primary adopter who provided his animals free access to feed and water by constructing bamboo fencing and a water trough (with a small investment equivalent to 150 AUD). The intervention resulted in an increase in milk production of 2 L/animal/day. This message was adopted by 40% of farmers which resulted in an average 25% increase in milk production per animal per day.

Calf mortality and growth was improved through the adoption of a set of health and feeding practices provided by our extension staff. These were refined in line with the extensive calf rearing trials the program instigated mentioned previously. Our advice was adopted by 70% of farmers, who were able to reduce mortality rates to 5% with a demonstrated potential to increase growth rates up to 340 g/day through to weaning. As a result farm profits increased by an average of 30%.

Milk marketing strategies: The project worked to develop a diverse range of profitable milk marketing strategies for individual and groups of farmers to increase their profit margins. For example Mr. Imtiaz Hussain (Mirzabad, Jhelum) started selling milk directly to consumers in a nearby town resulting in an increase of 25% in profits. A group of farmers in District Pakpattan who were previously selling milk to milk processing company adopted a co-operative group milk marketing strategy and opened a community milk shop in a nearby city. This resulted in a 40% increase in profit margin.

Value-addition: Female farmers were also engaged in different entrepreneurial activities related to milk value addition. Nusrat Perveen (village Kot Phaphra district Jhelum) who was previously making butter and desi ghee by traditional means, obtained a cream separator which saved 4 hours per day in processing time. This increased the profit margin from her milk by 50% through the labour and time saving. She then took the initiative to start a community based value addition entrepreneurship program with her profit margin increasing more than threefold.

Fodder seed: As outlined in the ‘scientific impact’ section of this report, Shoaib Tufail’s PhD research provided valuable knowledge to the scientific community and the farming communities in which he worked. An important outcome of the success of this work was that he managed to trigger a new funding opportunity to support additional initiatives for

the VBSE program in all of the seven project working districts. The key problem that was addressed by this project was to overcome the lack of quality fodder seed for growing fodder. The results of Shoaib's work showed a clear economic benefit to those farmers that were involved and followed 'best practice' agronomy principles provided by Shoaib initially and subsequently the project staff. These benefits included increases in fodder for feed (39%) and more than a doubling of seed production. Not only did this have an impact on the individual farmer, but it also has a great impact on the local community with farmers being able to access the quality seed previously unavailable to use on their own farms. Results from his work have shown that one year after the completion of his research two-thirds of the farmers are continuing to engage in the VBSE model along with agronomic practices recommended by Shoaib's research (number of fodder cuts, sowing rate, nitrogen fertilizer, sowing time). This demonstrates the sustainability of this model which has potential to continue for greater than five years.

A fodder success story: Mr. Muhammad Hussain, village Jagu Wala district Kasur, had a progressive mindset and as a result adopted our messages and benefitted significantly from the VBSE project. Mr. Hussain stated that "I became member of ASLP Dairy Project in 2011 and took full advantage through their regular trainings and allied extension activities organized. It would be very hard for me to get access to improved fodder seed varieties as well as access to information about agronomic practices without the help of the project. This helped me to earn extra profit of AUD 586 per acre from berseem seed as well as obtaining quality fodder for my animals". This is just one story out of a string of success stories in the VBSE project. A report outlining the impact of this project can be seen in the appendix of this report.

8.3.2 Social impacts

The project worked on extension methods involving the whole family including the farmer as well as the women and children in the household. A total 60 training sessions were provided to female and male farmers on improved dairy farm practices. A case study of one farm provided the story of Mr. Mohsin Riaz, a 16 year old student in District Jhelum. Some time ago, Riaz's father's was injured while chopping fodder leaving the farm to Riaz to run and hence, he could not continue his studies. By adopting improved farm practices such as free access to water and feeding, Mohsin Riaz was able to save sufficient time to continue his education.

Community farming: The community based approach used within the extension program provided a forum for discussing and resolving their social issues. It has also provided farmers with the opportunity for sharing their various experiences and success stories so that these can be passed on to improve the livelihoods of other farmers. A community farm was established at Pattoki where 10 to 12 farmers collectively reared their animals. After building their individual shaded feed pens on the site at the edge of the village, they began to co-operate with the chopping of forage and sharing other equipment. The co-operation then extended to collecting their milk together to sell directly to consumers in the local village, which attracted a 20% premium for milk sold. Some of the principles that were learnt from this initiative were:

- There needs to be a valid economic rationale for the development of a community farm.

- The financial management of the farm needs to be left with the farmers themselves. The extent of input from project staff needs to be confined to their advisory role, with decisions made by the farming community as a whole.
- Direct funding must not be provided to the community: they need to have and feel that they have ownership of the collective operation.
- There must be solid economic, social, cultural and environmental reasons for members in a community to work together.
- Participating community members must be selected carefully based on their positive attitude, progressive thinking, potential to work together and resilience to share in the financial outcomes of the enterprise.

Engaging children: It is important that positive outcomes are achieved for the whole family including the women and children in any participating village. The school teacher assumes an important role in disseminating extension material with a focus on the material that is most likely to fire the imagination of the children. While children will not understand the finer points of financial management, they will be captured by ways of looking after the family calves. In District Pakpattan, 13 children raised their calves according to project guidelines on their own farms. The live-weight of each calf was recorded at birth and after 80 days, with the highest live-weight achieved being 99kg growing at 430g/day. This community engagement and the involvement of children demonstrated the simplicity in rearing calves which lead to extremely high adoption rates of the extension recommendation in this location.

Collateral learning by farmers unwilling to participate directly with a co-operative activity is an important aspect of community farming. The unregistered farmers were the neighbours/friends of our registered farmers and occasionally attended our monthly extension workers training meetings. The results of the project's impact assessment study showed that these unregistered farmers had adoption rates on average 20% higher (but up to 40% higher with some recommendations) than the traditional farmers in the same village (who had no link to the extension program). This again highlights the reach and potential scale of the extension program to both registered farmers (who receive a high-intensity extension approach) and as well as their friends/family/neighbours (who receive a lower-intensity extension program)

8.3.3 Environmental impacts

The management of animal waste to ensure efficient nutrient recycling to the cropping operation formed an important aspect of the strategy. Our messages extended to the appropriate disposal of dead livestock to minimise disease transfer.

The dairy team collaborated with the Social Research Team to explore the installation of pilot biogas units to supply a clean energy source supporting up to 4 families per unit. The installation of biogas systems established at Jehlum (Master Imtiaz) based on the use of animal excrement resulted in a marked reduction in wood burning. A more effective nutrient recycling policy for crop production also resulted from this program.

The VBSE fodder research program promoted best practise agronomy and crop rotation with nitrogen fixing plants which promoted soil health and reduced the need for nitrogen fertilizer.

8.4 Communication and dissemination activities

Date	Event	Researchers (M/F)	Field officers (M/F)	Farmers (M/F)
Jan 2011 – Dec 2015	Farmer discussion groups with both male/female registered farmers in 56 villages every 6 to 8 weeks	1/1	1//0	~15/15 per village (total 750/750)
Feb, 2011	Nutrition focus group (NFG) meeting for feed calendar development	19/5		
July, 2011	3 rd International conference SAADC, Thailand	1		
Aug, 2011	Expert workshop of nutrition focus group (NFG)	17/4		
Aug, 2011	Extension worker training workshop at Sarsabz farm	3/6	23/0	
Feb, 2012	Farmer festival in District Pakpattan	14/8	2/0	850/0
Feb, 2012	Student forum at UVAS	47/17		
July, 2012	4 th Extension worker training workshop on animal reproduction	7/6	26/0	
July, 2012	Flood relief activities in Sindh	5/2		150/0
Nov, 2012	15th AAAP Animal Science Congress, Thailand	3/1		
Nov, 2012	5 th Extension worker training workshop on healthy calf rearing	6/5	26	
Nov, 2012	2 nd National Islamic Microfinance Conference, Lahore	1		
Apr, 2013	Nutrition focus group meeting	19/3		
Apr, 2013	International symposium on buffalo research and development, UVAS	1		
June, 2013	Capacity building workshop, Islamabad	8/4		
June, 2013	Ag-capability workshop	4/4	18/0	
July, 2013	4 th International conference	1		

	SAADC at Lanzhou, China			
Oct, 2013	Breeding and genetics workshop on Sahiwal cattle, UVAS	5		
Oct, 2013	Biostatistics workshop	23/8		
Oct, 2013	Extension worker training workshop	6/5	26	
Nov, 2013	Farmer festival, Pattoki	8/4	4/0	350/0
Nov, 2013	Organized a Nutrition Focus Group (NFG) meeting in order to develop the 'Agronomy practices' booklet	23/4		
Feb, 2014	Think tank meeting	16/5		
Mar, 2014	"Save the calf" seminar, Sindh	14/6	10/0	50/0
June, 2014	Ag-capability workshop	4/4	18/0	
Nov, 2014	Farmer festival, Pattoki	9/4		462
Apr, 2015	Final term review	12/5		
July, 2015	Ag-capability workshop	4/4	18/0	
Aug, 2015	Extension worker training workshop, Peshawar	4/4	23/0	
Oct, 2015	Dairy project final forum	62/23	4/0	5/4

9 Conclusions and recommendations

9.1 Conclusions

Objective 1: The ASLP Dairy Project has successfully completed a thorough investigation into the establishment, development, implementation and subsequent impact assessment of an extension program integrated within the Livestock Departments of Pakistani provincial Governments. The impact assessment study has shown that adoption rates of registered farmers (direct beneficiaries) are significantly higher than traditional farmers. This illustrates that the investment into the extension program had a positive impact on the target group of farmers leading to subsequent benefits on farm such as improved animal health, production and farm profits. In addition to our impact on project registered farmers, a “ripple effect” was observed in neighbouring (unregistered) farmers. These farmers demonstrated an increased awareness and capacity to change by replicating recommendations they had observed on registered farms. This “ripple effect” demonstrates the potential reach of an extension program such as the one implemented within this project.

The characteristic features of this extension model are:

- Well trained and supported extension officers participating in on-going training and reflection opportunities to encourage a positive learning environment.
- Community mobilization and engagement with continuous interaction to establish and build strong relationships based on trust.
- A whole-family approach to extension targeting the men, women and children of farming households.
- An incentive free program promoting community learning, adoption and adaptation on smallholder farms.
- An approach which targets smallholder dairy farmers and integrates the different components of their farming system to reduce input costs, increase milk production and entrepreneurial strategies to sell produce for greater profit margins.

Objective 2: Using a village based seed enterprise model smallholder farmers engaged with the project increased their fodder seed production by 200% and fodder yield by up to 40%. Profitability of this enterprise can lead to increases in financial returns per unit area that are up to four times the value of other major crops. This also provides quality forage seed for neighbouring smallholder farmers within the same community.

Objective 3: The project successfully conducted a series of research trials on calves of native dairy breeds including Sahiwal cattle and Nili Ravi & Kundi buffalo to demonstrate profitable calf rearing strategies. The project has also promoted the concept of conducting research at the farmer’s doorstep to ensure they “experience” and engage with the research outcomes. These trials clearly demonstrate that mortality rate can be reduced to less than 5% and an average daily weight gain of 450 g is achievable under the field conditions of Pakistan. Furthermore, case studies of farmers have shown that engaging in ‘improved’ calf rearing practices can be rewarding both financially with short-term sales as well as long-term benefits linking calf growth with longevity and increased lifetime milk production.

Objective 4: Different profitable milk marketing strategies have been introduced to families in our co-operating villages. Families who adopted these entrepreneurial activities have increased their profits from milk by up to two-fold. These include the production of yoghurt, ghee, sweets, ice-cream and lassi. Importantly, direct marketing of milk to the consumer has allowed the farmer to retain the profit margin normally passed to small volume milk collectors or dhodis to on-sell their product.

Objective 5: The project's approach of involving post-graduate students in research on the applied issues needing to be resolved for adoption by smallholder farmers remained a highly successful strategy for our project. There are more than 20 such students who have completed their research work and these outcomes have been incorporated in our extension material and published in high impact factor journals. The project also engaged in an extensive internship program which was a viable and successful way to train young people, link in with possible staff for the future and provide valuable enthusiastic team members to boost the ranks of our project team. This capacity building component is making a substantial contribution to the next generation of trained manpower entering the livestock sector of Pakistan. It is also providing further training opportunities in research and extension for talented young staff in overseas educational institutes.

9.2 Recommendations

Objective 1: The extension model developed by the project is a comprehensive package of training and extension material. However, this package cannot be simply scaled out throughout the country. To run an extension program like this successfully, it needs to be supported by an organisation that is willing to assume a dynamic role in leadership in further building on the project's successes. This will involve the continuous development and refinement of extension material, on-going training for extension personnel and evaluation of program activities to ensure positive impacts are translated to farming communities.

The project thus recommends that Government Livestock Departments or other organisations involved in extension take ownership of this extension model and in a systematic process incorporate its components within their own organisations. Initially this would involve training extension officers and trialling community engagement and extension services in targeted areas. Following this, the program can be scaled out with trained personnel from the organisation. Applied research needs to continue to target specific limitations to smallholder farming operations and the findings translated into further extension messages and materials.

Ideally the government livestock departments need to engage closely with universities who can provide the students, their academic supervisors and facilities to collaborate on research programs. Research and extension staff may be shared across the institutes to ensure full integration of programs. This will require a model for research funding crossing institute boundaries. Livestock Department extension networks as well as NGO and private sector groups would then be responsible for the dissemination of new extension messages. Such a joint program would require a co-operative management committee to maximise the efficiency of outcomes reaching farming communities.

Objective 2: As farmers, field officers and extension organisations become more engaged in the dairy industry they are becoming more aware of the necessity of animal nutrition and feed. This has led to dramatic increases in demand for more quality feeds. A

key challenge to increasing fodder availability remains the availability of quality fodder seed to smallholder farmers. The village-based seed enterprise system trialled within this project has the capacity to offer an entrepreneurial activity previously considered to be the domain of commercial seed companies. Retaining income from seed sales within local communities can do nothing other than increase their prosperity and improve livelihoods. This activity requires further nurturing and would benefit from private sector engagement and could involve forming seed grower groups selling quality seed collectively.

Objective 3: The outcomes of this project highlighted that calf mortality and growth rates could improve significantly creating opportunity for smallholder farmers to better utilise this resource for greater dairy and beef production. In order to improve smallholder farmer profits from this resource, clearer and more profitable marketing opportunities need to be identified. This would require a value chain analysis of the distribution channels linking smallholder farmers to potential markets and would need to assess opportunities for premium pricing for superior quality produce to ensure viable profit margins.

Expertise needs to be developed for extension staff and leading farmers to understand how profitable marketing strategies are developed. The most effective way of achieving this objective is for University and Government Departments to work co-operatively to overcome the challenges within this growing sector. The key to success will be the refinement of cost-effective feeding strategies that support the rearing of female calves to puberty to enter the milking herd and male calves to grow to live weights acceptable for animals to enter feedlot operations. In essence extension training needs to encompass cost-effective feeding strategies that support the growth of animals to service the needs of both the dairy and beef industries.

Objective 4: Adopting group and direct marketing strategies will be important in enhancing profit margins of smallholder dairy farmers. Governments should remove fixed pricing policies and allow free market forces to determine the price returned to the producer for the sale of high quality product. Tariff protection provided by the government against imported or “dumped” milk powder should be strongly encouraged to allow farmers to sell their milk beyond the cost of production.

Objective 5: The education process from children in primary schools through to ongoing training for experienced extension staff needs to remain a primary objective of the organisations we have engaged with. Didactic or “top down” educational methodology is outdated and must continue to be replaced by experiential teaching methods. The education process itself must remain as a research target for the future. Any project engaging in applied research or extension would benefit significantly from linking in with a University institution and forming an alliance to promote student and researcher involvement. This creates a rich learning environment for both the project and University personnel leading to greater impact within the project as well as in the long-term due to the support and development of early career researchers.

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11 Appendixes

11.1 Appendix 1. Impact assessment report: Village-based seed enterprise project.

Background

Pakistan is blessed with diversified type of Livestock. Livestock contributes about 11.8% in Pakistan's GDP and about 56.3% towards total Agricultural GDP. The total livestock population (Buffaloes, Cattle, Goat, Sheep, Asses, Camels, Horses and Mules) is 181.2 million heads in Pakistan having a gross value of more than 800 billion rupees (Government of Pakistan, 2015). Livestock population is increasing at the rate of 4.1 percent per year and accordingly its feed requirements are also increasing. It not only provides food security through the supply of milk (52.6 million liters) and meat (3696 thousand tonnes) but also self-employment (> 43%) for both men and women to the rural population of Pakistan. It also plays a vital role in poverty alleviation of resource-poor livestock farmers. (Government of Pakistan, 2015). The role of livestock in the rural economy may be realized from the fact that 30-35 million of rural population is engaged in livestock raising, having household holdings of 2-3 cattle/buffalo and 5-6 sheep/goat per family which help them to derive 30-40% of their income from it. Further, livestock production supporting 8.42 million rural households with the primary objectives of meeting daily household dietary requirements (Afzal, 2010).

Fodder is the main source of feeding for livestock in Pakistan and fodder crops produced the cheapest feed for livestock. The fodder production in Pakistan is primarily through primitive and traditional cultivations resulted in low production of fodder and does not meet the fodder requirement (both for quantity and quality) resulting that the animals are undernourished. Shortage of fodder is the main limiting factor responsible for low animal productivity in the country. The average yield of fodders in Pakistan was 25.2 t/ha per annum (Sarwar et al., 2002) and further reduced to 22.6 t/ha in the recent years (Government of Pakistan, 2007), primarily because of the unavailability of the quality seed (UI-Allah et al., 2014, Afzal, 2010). Further, use of substandard methods of cultivation, poor crop stand, malnutrition and lack of high yielding varieties lead to low fodder production at farm level. Moreover, inappropriate harvesting management of fodder crops resulted in low productivity and quality of fodders in Pakistan.

Pakistan is not self-sufficient in forage seed and the amount of imported forage seed is increasing every year. In 2013-2014, the amount of forage seed imported (mainly Berseem and Sorghum forage seed) increased by 230% (Farooq, 2014) and this was at a significant cost to smallholder farmers. There is a clear need to increase farmers' capacity to produce quality seed at the farm level and disseminate through an informal forage seed supply system which will supply quality seed to farmers and complement the existing current formal seed supply system of Pakistan.

Availability of improved seed of fodder crops is one of the major limiting factors in fodder crops production in the country. It is estimated that only 5 to 10% areas of fodder crops is grown with improved seed (Government of Punjab, 2010). Considering the subject of improved seed production, it involves a number of interlinked systems, agro-climatic conditions, specific crop adaptation to environment, socioeconomic factors including prices and marketing, crop management and production technologies (UI-Allah et al.,

2014). Unfortunately there is neither private nor government sector involved in the seed business of fodder crops as it is in case of vegetables and cash crop. Only 113 Metric tonnes (2.15%) of fodder seed produced locally in Pakistan, while the rest of 5124 Metric tonnes (>97%) was imported from overseas (Government of Pakistan, 2015). The requirement is fulfilled either by importing seed from overseas or by purchasing substandard and uncertified seed by the farmers without any consideration of seed production guidelines.

Australian Sector Linkages Program (ASLP) under the umbrella of Australian Centre for International Agricultural Research (ACIAR) in collaboration with Charles Sturt University, Australia and University of Veterinary and Animal Sciences, Pakistan introduced an idea of village-based fodder seed enterprises. Mr. Shoaib Tufail (PhD scholar) from Charles Sturt University selected eight volunteer farmers from project registered farmers in the four villages of the Punjab province (two from Okara district and two from Kasur district) for his village-based fodder seed enterprises (VBSEs) study. The objective of his study was to develop local forage seed enterprises to provide high quality seed through farmer participatory research approach; to enable smallholder dairy farmers to produce sufficient forage to maintain the productivity of their animals throughout the year.

In Pakistan, there are annual forage gaps totalling four months of the year when the smallholder farmers are unable to produce sufficient fodder for their livestock, including the depths of winter and again at the height of summer. Dairy farmers spend most of their money on feeding their animals for growth. Approximately 60% of all expenses on dairy farming are spent on the provision of appropriate feed according to the requirements of animals. He selected Berseem clover (*Trifolium alexandrinum* L.) as a test fodder crop during his study which is an annual forage legume widely grown under rainfed or irrigated conditions. Berseem clover crop is adopted by more than 90% of the smallholder farmers of Pakistan and produced more than 50% of the green fodder annually (Anwar et al., 2012). The crop is sown in the month of October and owing to its excellent regrowth ability, it is mainly used as daily green feeding from winter to late spring (November to June). Use of improved variety seed is a major problem for low forage yield of Berseem clover. In his study he trained the selected farmers the art of seed production of Berseem clover from seed selection till seed harvesting. The results of the study showed that this not only increases the farm productivity by reducing fodder shortage but also generates extra income for profitability and sustainability of their farms.

An impact assessment survey was carried out with the forage seed entrepreneurs (8 seed producer farmers), produced and disseminate the Berseem clover seed through VBSEs. The assessment was done through a face to face interview based on a questionnaire. It was observed in the survey (Table 1) that the improved agronomic practices were adopted by the smallholder dairy farmers after village based seed enterprise trials conducted by Shoaib Tufail (Charles Sturt University).

Table 1: The comparison of the adopted improved practices before and after village-based seed enterprises by smallholder farmers in the districts of Kasur and Okara, Punjab, Pakistan.

Agronomic practices	Before VBSE	After VBSE
Use of Improved variety seed of Berseem clover	Smallholder farmers used low yielding indigenous local varieties. These varieties produced less forage, dry matter and seed yields.	Improved seed of Agaitti Berseem-2002 variety was obtained from the government plant breeding research station (Fodder Research Institute, Sargodha). All the surveyed farmers were satisfied with research station variety when they compared with local and market seed varieties. There was about 36.89% (55.29 vs 75.67 t/ha) increased in forage yield and 82.46% (171 to 312 kg/ha) increased of seed yields were recorded from this improved variety. Another improved variety named “Anmo” Berseem was also introduced by one of the smallholder farmers on his field which complement the importance of improved quality seed and farmer’s willingness to adopt this practice at farm level. These varieties have the potential to increase fodder yields 2-3 times compared to local ones currently used. One of important character of this variety is the availability of forage cuts till 30 th May.
Sowing time	Most of smallholder dairy farmers sowed Berseem crop in mid-September or late in October. Early sowing resulted in seedling burning due to high temperature while late sowing gave stunted growth due to low temperatures resulted in poor yields. Late sowing often hampers the fodder yield because the onset of winter interferes with the crop growth in early stages.	Now all the smallholder dairy farmers sown Berseem crop during first week of October which is optimum time for Berseem sowing. This gives better growth and higher yields of Berseem clover. Further, farmers getting the first cut after fifty five or sixty days after sowing. The practice of getting 5-6 cutting related to early sowing in the month of October.
Use of Inoculum	It was observed that smallholder dairy farmers were not well aware of inoculum practice.	Berseem is grown for the first time using seed inoculation in VBSE trials with <i>Rhizobium trifolii</i> bacterial culture. However, its availability is still a big problem and the VBSE farmers using soil from an old Berseem field and spread on the new Berseem field before sowing. Most of smallholder dairy farmers used last year Berseem field’s soil as described in the VBSE trials.

<p>low use of N-fertilizer</p>	<p>Smallholder farmers used Urea fertilizer after every cut which resulted in excessive use of nitrogen fertilizer. They have no knowledge about Berseem as leguminous crop that hosts the <i>Rhizobium</i> bacteria in nodules on its roots. These bacteria fix atmospheric nitrogen and make it available to Berseem plants.</p>	<p>Nitrogen fertilizer (urea) was not used after every cut except initial dose of nitrogen fertilizer which improves seedling growth. There was no difference in forage yield but there was lower cost of production as a result of not using excessive urea fertilizer.</p>
<p>Cutting Schedule</p>	<p>Smallholder dairy farmers did not follow any cutting schedule. They usually cut the Berseem at earlier stages which affects the Berseem crop stand and persistence and also the final forage and seed yields.</p>	<p>Smallholder dairy farmer followed the VBSE trial's cutting schedule. First cut was taken after sixty days and later cuts were made after 30-35 days interval. Cutting frequency, a critical factor influencing harvested forage yield, nutritive quality of forage and stand persistence. It is also very important in producing maximum seed yield of Berseem clover.</p>
<p>Last forage cut</p>	<p>Smallholder dairy farmers usually left the crop for seed purpose during last week of February after taking 2-3 forage cuts.</p>	<p>Smallholder dairy farmer took 4 forage cuts and then left the Berseem crop for seed purpose. This gives an extra forage cut and length of growth period before flowering, seed harvest and availability of pollinator was coincided. This resulted in higher seed yield.</p>
<p>Use of Honey bee</p>	<p>Smallholder dairy farmers were not well aware of honey bee use at the time pollination.</p>	<p>With the introduction of honeybees to increase the efficiency of pollination more than doubled seed yields, which demonstrated in VBSE trial. There was problem of availability of honey bees in the market, but at the time pollination natural available honey bees in the area helps the farmers to accomplish this task. However, the bee populations are unknown and declining with the extensive use of neonicotinoid pesticides (Imidacloprid).</p>

Capacity building of smallholder farmers

There are various approaches that have been used to improve smallholder dairy farmer's livelihood system, one of them would be the capacity building of farmers with a view of improving their knowledge and skills of fodder production. With a focus on improving farm profits, farmers were equipped with a range of tools to enable them in order to improve their farming system and to evaluate the productive changes in their farming system. Due to the declining growth rates in agricultural productivity, there is impetus not only for increased investments in infrastructure, research and development, but also on capacity building of the farmers. Improving the skills and knowledge of farmers, even beyond schooling, will increase their productivity, raising output, enhancing household incomes and thus reducing poverty.

The village based seed enterprise (VBSE) aims to build capacity of smallholder dairy farmers to improve their income and household welfare. The focus of the trials was on smallholder dairy farmer's integrating forage and seed production system. This increased the capacity of participating farmers to improve the management, profitability and long-term sustainability of this integrated system through continuous improvement in their creativity, decisions, processes, practices and performance. One of the important aspects of VBSE is the participatory approach to research and development which worked well together in the process of learning of VBSE trials and then development of VBSE itself at village-level. During the trial their problems and needs were identified in order to improve the integration of forage and seed production system with the local and improved knowledge of growing Berseem clover on their farms. There are three areas of knowledge and skill which were improved as a result of VBSE activity are; Analytical skill, technical skill and economical skill of smallholder farmers.

1. Fodder production increased

On an average, about 37% of Berseem forage yield increased of all smallholder dairy farmers from all forage cuts due to use of improved agronomic practices (especially timely sowing, use inoculum, use farm yard manure (FYM) and timely harvesting). All the VBSE farmers sold out extra forage at premium price (3.50 vs 2.50 Rs/kg) to other neighbor farmers and generate additional incomes. BerseemFurther, Berseem clover production at VBSE farms with timely sowing and follow the trial cutting schedule, farmers produced up to 12.35 t/ha DM Berseem.

2. Seed production

Unavailability of seeds of improved forages varieties is a major problem for optimum forage production. The urban dairy industry had never flourished to the amount to create a big demand for forage crop seed. There is no well-planned and regular system of seed collection and multiplication of improved forage crop varieties in the country. Under VBSE trials the production and marketing aspect has been identified and now all smallholder dairy farmers of the survey produced their own seed of Berseem clover. They produced about 296 – 346 kg/ha (average 312 kg/ha) and were more confident after adopting improved agronomic practices of forage and seed production. The VBSE farmers now selling Berseem clover seed to village farmers at the rate of PKR 425 per kg which is premium priced compared to market rate of PKR 250 per kg. Further, one of the VBSE farmer who was unable to produced seed at the time of VBSE trials due to financial and time constraints, has been motivated and currently producing Berseem clover seed (237 kg/ha) and selling through VBSE.

3. Potential impact on farmer income

The main emphasis of VBSE was improving farmers' ability to assess the profits of their enterprises and ultimately improve their whole farm productivity and profitability. There was a need to build the capacity of farmers in assessing various actions and opportunities in livestock production using simple economic analysis. On adopting the improved agronomic practices of growing Berseem forage and VBSE technology, the seed entrepreneurs (farmers) now generating average net incomes of 314,358 Rs/ha (4366 A\$/ha), which is 4 times higher than they earn from any other cash crop grown in the region. The partial budget analysis of VBSE farms further revealed that the average benefit:cost ratio was recorded 4.78:1 with marginal rate of returns of 378% which is well above the minimum benchmark of 40-100% (Shah et al., 2011) for farmers acceptance of adopting a new technology at their farms to the majority of situations considering capital cost, risk and inflation rate in Pakistan.

Constraints and Challenges

- Seed of improved varieties is not available to farmers. Only one fodder research institute is working in Punjab province which cannot fulfill the requirement of farmers in the whole province.
- Pest attack such as *Helocoverpa armigera* (Hubner), *Tylenchorhynchus vulgaris* and *Heliotylenchus dihystra* cause significant loss of fodder and seed yields. With the use of pesticides, the honeybee population is declining and this is reducing the efficiency of pollination; this has resulted in poor seed setting.
- Most of the smallholder dairy farmers have a low level of basic education and find it easier if there are best-practice examples that they can follow.

Conclusion

In conclusion, all the VBSE smallholder dairy farmers (seed entrepreneurs) are very satisfied after adopting improved practices of growing Berseem clover (both for forage and seed production). The forage yield increased from 55 to 75 t/ha (37 % increase) and seed yield increased from 171 to 312 kg (82% increase) resulted by the adoption of VBSE technology at farm level. This not only increases their farm productivity by reducing fodder shortage but also generates extra income for the profitability and sustainability of their farms. The average net income of PKR 314,358 per ha (AUD 4,366 per ha) was generated on VBSE farms.

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