MILK Symposium review: Identifying constraints, opportunities, and best practices for improving milk production in market-oriented dairy farms in Sri Lanka*

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ABSTRACT

Dairy is the most important subsector in the Sri Lankan livestock industry, due to the need to address the growing demand for fresh milk and milk products, and because of its potential influence on the rural economy. The USDA Food for Progress program awarded a 4.5-year Market-Oriented Dairy project to International Executive Service Corps, a not-for-profit organization based in Washington, DC. The objective of the Market-Oriented Dairy project is to support Sri Lanka's dairy sector and catalyze sustainable growth by strengthening the dairy sector through better technological, financial, and management practices benefiting all stakeholders and consumers along the dairy value chain. The University of Florida is working with International Executive Service Corps as technical experts in conducting dairy value chain assessments, identifying gaps and challenges in dairy management practices, extension services, milk quality management standards, and artificial insemination services. Assessment of the dairy value chain in 2018 identified a lack of good quality and quantity of feed, along with poor dairy management practices and ineffective extension services as major constraints to improving dairy productivity in Sri Lanka. In addition, lack of national milk quality standards that are consistent with international benchmarks and inadequate cooling facilities are significant challenges to improving milk quality. The nutritional status of cows is not suitable for optimal reproductive performance, compromising the success of artificial insemination in Sri Lanka. Based on these findings, we developed a dairy assessment tool and provided comprehensive training sessions targeting extension agents,

veterinarians, and farmers to promote best practices in dairy management. Beyond training, however, industry support for standardization and monitoring of milk and feed quality are needed, providing opportunities for private investment to support the dairy industry. Similar opportunities are available for forage production and delivery to producers. The broader aim of the Market-Oriented Dairy project intervention is to reduce Sri Lanka's dependency on imported milk and contribute toward the goal of a safe, self-sufficient fresh milk supply.

Key words: dairy, Sri Lanka

INTRODUCTION

Background

Since the end of Sri Lanka's civil war, the country has enjoyed increasing economic growth and enhanced incomes and purchasing power for many of its citizens. During this phase of economic development, the government has placed renewed emphasis on strengthening the dairy sector to reduce the demand for imported dry milk powder as consumer demand for dairy products begins to increase (Vernooij et al., 2015). The government of Sri Lanka set a nationwide goal of becoming self-sufficient in dairy. Based on reports from the Agriculture and Environment Statistics Division of the Department of Census and Statistics in Sri Lanka (<http://www.statistics.gov.lk/agriculture/>), the country's dairy sector has responded to growing demand by increasing milk production from 202 million liters in 2007 to 467 million liters in 2018. However, Sri Lanka is still importing 53% of its total domestic supply of milk and milk products (excluding butter). For self-sufficiency, more concentrated efforts targeted at addressing the main barriers to sustainable dairy sector development, including not only milk production but also milk quality and safety, particularly at the local level, are needed.

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for Livelihoods Development (**SOLID**) project from 2013 to 2016, focusing on increasing economic opportunities for vulnerable families in Sri Lanka. The project's activities were primarily focused on the dairy, horticulture, and poultry sectors. Dairy farmers working with the SOLID project reported average herd expansion from 3 to 7 cows (133% increase) and improved monthly milk production from 404 to 503 L (27% increase). The improvements in the dairy sector were attributed primarily to the effectiveness of introducing high-protein sorghum silage. The USAID-funded SOLID project that culminated in 2017 was not entirely focused on dairy activities and dairy entrepreneurship; however, project activities enhanced the capacity for milk production and set the stage for further development of the dairy industry, particularly development of "dairy-centric" entrepreneurs on medium- and large-scale operations to ramp up production of fluid milk (Reimer et al., 2017).

The USDA Food for Progress program funded a 4.5-year Market-Oriented Dairy (**MOD**) project, implemented by International Executive Service Corps (Washington, DC) in collaboration with the University of Florida (Gainesville), Sarvodaya (Moratuwa, Sri Lanka), Global Dairy Platform (Rosemont, IL), and the Small Enterprise Assistance Fund (Washington, DC). The objective of the MOD project is to increase the productivity of Sri Lanka's dairy sector by increasing availability of inputs for dairy farmers in a way that can be sustained beyond donor support and to improve food safety and quality of dairy products at the local level. The broader goal of the MOD project intervention is to be able to reduce the nation's dependency on imported milk, to reduce the pressure on foreign exchange required to purchase milk powder, and to contribute toward the goal of self-sufficiency in fresh milk supply, with milk production of participating farmers and farms anticipated to increase from 38,525 to 87,820 t by 2022.

The cornerstone of the MOD project is to build on the market potential for dairy development with interventions linked to the needs and challenges of the sector, to have greater and more sustainable effects on the dairy enterprises. The market-oriented nature of this project is aimed at developing an entrepreneurial mindset among stakeholders across the entire dairy value chain, thereby encouraging public and private collaborations and delivering sustainable solutions for greater effects on dairy enterprises. The activities of this project are divided into 6 categories: (1) Capacity building: strengthening the ecosystem of agricultural extension services to improve dairy productivity, AI services, and developing the entrepreneurial mindset of participating dairy farmers; (2) Inputs: developing agrodealers and input suppliers to increase the amount of inputs (in-

cluding high-producing animals, fodder, and silage) for dairy farmers; (3) Financial services: leveraging public and private investment to improve investment in Sri Lanka's dairy sector, both through the establishment of an investment fund and by providing assistance to financial institutions to encourage lending in the dairy sector; (4) Market access: facilitating relationships between buyers and sellers of inputs in the dairy sector, as well as developing market linkages for dairy farmers seeking to move from the informal to the formal sector; (5) Training: establishing sanitary and phytosanitary standards to improve the quality and safety of milk produced, through training of farmers and collection center managers, increasing the demand for safe milk at the local level, and introducing new market-based incentives for meeting quality standards; and (6) Capacity building of trade associations, to strengthen the All Island Dairy Association of Sri Lanka. Hence, the goal of the MOD project is to increase agricultural productivity and to expand trade of milk and milk products in Sri Lanka. Because of the vast scope of the MOD project, this paper will be largely focused on the role of the University of Florida within the MOD project, and discussion will be restricted to activities 1, 2, and 5, with brief descriptions of other activities that are led by the MOD team in Sri Lanka. This paper is aimed at describing activities used for identifying the knowledge gaps and needs at individual and institutional levels in areas of dairy production, AI and reproduction, and milk quality. In addition, we focused on sharing recommendations to overcome the bottlenecks for improving dairy production in Sri Lanka.

MATERIALS AND METHODS

The role of technical experts from the University of Florida, in collaboration with MOD team members in Sri Lanka, was to improve dairy productivity and AI services by strengthening extension services, to increase improved fodder availability to dairy producers, and to promote best practices for handling milk and for testing the quality and safety of milk. While working on these activities, the University of Florida team, in collaboration with MOD team members, conducted a needs assessment survey, developed appropriate training modules for a "train the trainers" curriculum where needed, identified the correct beneficiaries, and conducted the required training.

Needs Assessment Methodology

Conducting a comprehensive needs assessment was required for identifying and addressing gaps in dairy

management practices and extension services, and AI training and delivery of AI services, and to assess prevailing raw milk quality standards and current practices for maintaining quality, and to provide recommendations for improvements. In addition, the assessment determined regional differences in dairy production and availability of animals (crossbreeds vs. indigenous breeds) in each of the 6 province areas (North, North Central, Central, East, North Western, and Uva Provinces) where the MOD project is being implemented. The technical experts from the University of Florida conducted needs assessment as well as assessment of existing extension resources by reviewing existing training materials on best practices in dairy management, including feed, silage, animal health, and AI. The methods, tools, and techniques promoted by the USAID-funded SOLID project, along with the final evaluation report of the SOLID project, were also reviewed. In addition, the methods and training materials of the Sri Lanka Department of Animal Production and Health (DAPH) and extension agents of large dairy companies, along with a dairy production manual developed by the National Steering Committee for Dairy Farmer Development, quality of feed and silage, and on-farm veterinary health and food safety interventions were reviewed.

The assessment team met with MOD dairy partner companies and their respective farmer groups, small dairy farm owners, input suppliers, feed manufacturers, private extension service providers, and relevant government officials. Specifically, meetings were scheduled with members of the Ministry of Rural Economy, managers of milk procurement industries, and representatives from the National Apprentice and Industrial Training Authority, the National Livestock Development Board, the Vocational Training Authority, and the All Island Dairy Association. Meetings were also scheduled with researchers from the University of Peradeniya and with veterinary surgeons at veterinary zonal offices, to receive perspectives on existing dairy production practices from academia and field veterinarians, respectively. The meetings of the assessment team were primarily focused on the MOD target areas of North, North Central, Central, East, North Western, and Uva Provinces.

The preliminary findings were validated through a presentation on findings and recommendation to the MOD technical team and partners, including provincial directors from DAPH. In addition, preliminary findings were shared with stakeholders for validation and to obtain additional input as required to initiate discussion on needs and how best to improve production, extension, AI, and quality and safety of raw milk. The final draft of the assessment report was prepared after

feedback from public and private committees formed by the MOD team in Sri Lanka.

Based on findings from the assessment report, training materials were prepared, addressing the key nutritional, reproductive management, and husbandry practices that have compromised dairy productivity in Sri Lanka (Table 1). In addition, training materials were focused on best management practices for hygienic milking, transport, and collection practices, targeting dairy farmers, bulk collectors, and milk chilling center operators (Table 1). The information for training materials was sourced from teaching resources available at the University of Florida, published literature in respective areas, and instructors' experience. Materials were presented in a format that is easily understood by a diverse audience. The preparation of training materials was followed by conducting training of trainers, who then delivered the training material to farmers in native languages (Tamil and Sinhalese).

Dairy Farmer Beneficiaries

The MOD project identified 3 key groups of dairy farmer beneficiaries for targeted assistance available through the project (Figure 1). The first group of farmers had dairy as their primary source of income, with fewer than 15 cows or producing a total volume of less than 25 L of milk per day from the farm. This group of farmers needed inputs toward scaling up productivity, best practices for milk quality, and accessing financial resources for scaling up their operation. The second group of farmers also had dairy as their primary source of income but had 15 or more cows producing more than 30 L of milk per day (total volume on the farm for all animals). These farmers were more productive and practiced intensive management. These farmers were considered candidates for private sector investment for scaling up dairy production. The last group of farmers were not dependent on dairy as their primary source of income and were selling milk informally. The MOD project activities planned to connect these farmers to the formal market to motivate them to shift toward the formal sector. In addition, the MOD project engaged with other beneficiaries, including managers and employees of milk collection centers, farmer cooperative societies, AI technicians, veterinarians, and farmers with potential to become medium-scale fodder producers.

Monitoring and Evaluation

The MOD project is ongoing, and the data on monitoring and evaluation (M&E) is still being collected; however, MOD has developed a robust and compre-

Table 1. Topics covered during training of trainers sessions implemented by the Market-Oriented Dairy project in Sri Lanka

Topic	Title	Demonstration
Dairy cattle productivity	1. Ration formulation	Ration formulation tool
	- Nutrient requirements of dairy cattle	
	- Importance of DM estimation	Near-infrared reflectance spectroscopy Penn State Particle Separator
	- Basics of diet formulation	
	2. Forage quality	
	- Existing forage resources in Sri Lanka	
	- Forage conservation	
	a. Making of good-quality silage	
	b. Silage additives	
	- Nutrient analysis	
	3. Feeding phases	
Dairy cattle management	- Calf feeding	Dairy assessment tool ¹ (Microsoft Excel-based tool for assessing and grading current practices at the dairy farm)
	- Raising replacement heifers	
	- Feeding transition cows	
	- Feeding lactating cows	
	4. Calf and heifer management	
	- Colostrum quality	
	- Growth rates	
	- Estrus detection and reproductive goals	
	5. Transition cows	
	- Managing metabolic disorders	
Milk quality	6. Lactating cows	Body condition scoring
	- Mammary gland physiology	
	- Stocking rate	
	7. Cow comfort	
	- Housing recommendations	
	- Heat stress abatement	
	8. Record keeping	
	9. Body condition scoring	
	10. Importance of milk quality training	Cleanliness and comfort Equipment maintenance Milking routine
	11. Best management practices	
	- Cow cleanliness and comfort	
	- Milking routine	
	- Milk equipment cleaning and maintenance	
	12. Management of mastitis	
Reproductive management	- Definition	Female reproductive anatomy
	- Causes and risk factors	
	- Treatment and prevention	
	13. Female reproductive anatomy	
	14. Estrous cycle	
	- Estrus synchronization	
	- Induction of ovulation	
	- Heat detection	
	15. AI	
	- Timing of AI relative to heat	
	- Timing of AI relative to calving	On-farm cow restraint, handling
	- Procedures in AI	AI procedure demonstration
		Pregnancy diagnosis by rectal palpation
		Use of ultrasound for pregnancy diagnosis

¹Dahl and Hendrickx, 2018. Microsoft Corp. (Redmond, WA).

hensive M&E methodology and process to capture all required information on the 22 standard and customized project indicators. Efforts of an M&E specialist supported by an M&E survey company have ensured timely collection of data from numerous stakeholders, project staff, and partner organizations. The M&E specialist, along with the MOD team in Sri Lanka, used baseline surveys for farmers and worked with externally contracted enumerators to enter the data into the M&E database system. To monitor progress, the

M&E specialist and the MOD team are managing and supervising the design and implementation of multiple surveys, including monthly sales volume, milk quality parameters with dairy processors, fodder and cultivator surveys, large farm surveys, and others. Monitoring and evaluation are based on robust and dynamic databases to ensure quality and accuracy of data collection and to capture and report on progress of the project. Dairy farmers and commercial fodder cultivators use a Mentoring and Monitoring Form to track their progress pe-

riodically. Similarly, the performance of large farms is tracked using a data collection form that captures their milk production and sales value details (Appendix 1).

RESULTS AND DISCUSSION

Needs Assessment and Recommendations

Based on the comprehensive needs assessment report, key bottlenecks preventing efficient functioning of the dairy value chain were identified and recommendations were provided, as shown in Table 2. Overall, great need exists to improve dairy productivity, extension, and AI services through sustainable access to inputs. In addition, improving milk quality and greater availability of quality safe milk needs to be prioritized. Specifically, challenges and recommendations were identified in the following areas.

Milk Production. Forages are an integral component of dairy cattle diets, and availability of good-quality forage is essential for optimizing rumen function and subsequent milk production (Waldo, 1986; Allen, 1996; Zebeli et al., 2012). Considering the importance of for-

ages, the lack of adequate quantity and good quality of forages were identified as major bottlenecks to dairy production in Sri Lanka. Similar findings were observed earlier, from a fodder study conducted by Wageningen University (Houwers et al., 2015). Natural pasture and browse are the predominant feed resources for domestic milk supply, and the tropical grasses used as feed resources, primarily Napier grass, are low in digestibility and crude protein, resulting in low productivity of dairy cows (Skerman and Riveros, 1990; Ibrahim et al., 1999a,b). Animals grazing on pasture are often supplemented with crop residues and rice straw, which are also of inherently low nutritional quality (Houwers et al., 2015). During the dry season, silage and hay are critically important for maintaining animal health and productivity. This is particularly important in the Eastern and Northern Provinces in Sri Lanka's dry zone, which has the lowest milk yields in the country at an average of 2.1 L per cow per day, and only 300 to 400 L per cow per lactation. High-producing dairy cows are incapable of sustaining their production levels without adequate nutrition, and fodder availability is an even greater problem than fodder quality (Waldo,

Figure 1. The key groups of dairy farmer beneficiaries in Sri Lanka identified by the Market-Oriented Dairy project. OPIC = Overseas Private Investment Corporation.

1986; Mertens, 1987). In an intensive management system, both forages and concentrates are fed to dairy cows; however, fundamental knowledge of optimum feed quantity and quality required to maximize production is lacking.

The USAID-SOLID project trained farmers for fodder cultivation and silage making to offset reduced availability of forages during the dry season; however, it is not uniformly practiced. Forages are supplemented with commercial concentrates in an effort to nutrition-

Table 2. Constraints, recommendations, and project activities in the Market-Oriented Dairy project in Sri Lanka

Needs/challenges	Recommendations	Activities
<p>Milk production</p> <ul style="list-style-type: none"> • Need for improved quantity and quality of fodder and silage • Adequate water available for dairy cows 	<ul style="list-style-type: none"> • Fodder/silage enterprises strengthened • Farmers trained on producing fodder and silage • Training programs to emphasize the importance of water availability for increasing milk production 	<p>Activity 2—Inputs: Develop agrodealers and other input suppliers</p> <ul style="list-style-type: none"> • Develop fodder/silage enterprises <p>Activity 1—Capacity building: Agricultural extension agents/ services</p> <ul style="list-style-type: none"> • Training on best practices for productivity
<ul style="list-style-type: none"> • Need for labs to evaluate nutritional value of feed resources • Nutrient database of locally available feed resources • Concept of nutrient-balanced diet formulation is totally lacking • Concept of using DM for ration formulation is lacking 	<ul style="list-style-type: none"> • Feed formulation ration application is proposed to assist dairy producers with balanced diet formulation • Nutritive value of local available feed resources will be analyzed at University of Peradeniya • Training programs on measuring DM content of feed ingredients using microwave oven 	<p>Activity 1—Capacity building: Agricultural extension agents/ services</p> <ul style="list-style-type: none"> • Training on best practices for productivity
<p>AI and reproduction</p> <ul style="list-style-type: none"> • Need for consistent availability and quality of AI and other veterinary services • Record keeping, conception rates, pregnancy rates, pregnancy per AI, and calving rates • Logistical limitations exist between observation of estrus and application of semen • Incidences of postpartum anestrus high due to inadequate nutrition • Lacking protocols for estrus synchronization 	<ul style="list-style-type: none"> • Gaps and challenges in AI services will be addressed by training programs focused on effective delivery of AI services • Trainees will include national AI trainers, veterinarians, livestock development instructors, public and private AI technicians • Training programs will be mix of classroom sessions and hands-on training at the dairy farms • Topics covered during AI trainings include female anatomy review, protocols of synchronization, AI principles, and endocrinology of the estrous cycle 	<p>Activity 1—Capacity building: Agricultural extension agents/ services</p> <ul style="list-style-type: none"> • Improve AI services
<p>Milk quality</p> <ul style="list-style-type: none"> • Need for improved practices at collection • Need for training in best practices at the farm level for quality in formal sector <ul style="list-style-type: none"> • Need for expansion of quality-based payments 	<ul style="list-style-type: none"> • Collection center managers gets access to financing for best practices for testing, quality • Farmers receive training on best practices of handling milk to maintain quality and meet standards • Promote quality-based payment systems to companies and cooperatives 	<p>Activity 5—Training: Sanitary and phytosanitary standards</p> <ul style="list-style-type: none"> • Training on best practices for milk quality <p>Activity 5—Training: Sanitary and phytosanitary standards</p> <ul style="list-style-type: none"> • Promote quality-based payments for milk producers
<p>Extension services</p> <ul style="list-style-type: none"> • Outdated delivery method and reliance on extensive (vs. intensive) management methods 	<ul style="list-style-type: none"> • Training extension workers • Develop mobile-based extension services to improve ability to reach dairy producers in hard-to-reach areas 	<p>Activity 1—Capacity building: Agricultural extension agents/ services</p> <ul style="list-style-type: none"> • Develop and roll out mobile extension services
<p>Dairy cattle management</p> <ul style="list-style-type: none"> • Record keeping and decision making by analyzing records is lacking • Limited understanding among farmers about cow comfort and subsequent effects on productivity • Guidelines for managing calves and dry cows are lacking • Limited knowledge about herd composition 	<ul style="list-style-type: none"> • Improve cow comfort—loose barn shed, water systems for heat stress abatement • Optimum herd composition is characterized by minimum 50% animals in milking and 85% dry cows pregnant • Training on best practices in dairy management, calf management, cow comfort is provided 	<p>Activity 1—Capacity building: Agricultural extension agents/ services</p> <ul style="list-style-type: none"> • Training on best practices for productivity

ally balance rations; however, on most farms, similar amounts of concentrate are offered to each animal regardless of physiological stage of lactation. The cost of feeding makes up 60 to 70% of the total cost of milk production, and without a good feeding program, dairy production is not cost-effective. Dairy cows that are managed extensively rely on pasture, which brings inherent issues of forage quantity and quality. Farmers trained during the SOLID project have started to cultivate fodder such as sorghum, CO3 hybrid Napier grass, and other grasses, thereby offsetting the reduced availability of good-quality forages during the dry season. Furthermore, fodder harvesting—that is, cutting and bringing fodder to the cattle for feeding—is labor intensive. This is a disincentive for farmers to switch from extensive management to more intensive management. In addition, Sri Lanka has a shortage of land for growing fodder. This gap of feed supply for farmers who are willing to invest more in feed can be filled by feed enterprises. The MOD is in the process of setting up small silage entrepreneurs at the provincial level. To date, 3 such entrepreneurs have been established in Northern, Central, and Uva Provinces.

The evaluation of nutritional value of feed resources is of fundamental importance, as it determines whether animals are receiving nutrient-adequate diets (Gomes et al., 2011). However, the concept of nutritional assessment of feed resources was found lacking, and this is further compounded by a lack of analytical facilities at the provincial levels where the farmers are located. Understanding of the concept of using specific nutrients to develop a balanced ration is completely lacking. It is not clear what standards are followed for feeding high-yielding dairy cows at the larger farms.

Estimating moisture content of the feed is important, as it affects nutritional quality of the feed because nutrients required by animals for maintenance, growth, pregnancy, and lactation, are part of the DM portion (Thiex and Richardson, 2003). The importance of measuring DM content of various feed ingredients, especially forages, is completely lacking among dairy producers, regardless of the size of dairy operation.

AI and Reproduction. Reproductive performance of dairy cows is affected by a multitude of factors, including energy balance, BCS, milk yield, disease, and reproductive management (Caraviello et al., 2006). A cornerstone of monitoring and improving reproductive performance of any dairy cow is the maintenance of meticulous records. Based on previous Sri Lankan records, a total of 109,008 AI procedures were performed in 1996, resulting in a total of 18,193 calves born, providing an average of 6 AI procedures for every calf born (Abeygunawardena et al., 2001). However, conception rates were reported at 50%, suggesting a conflict in

those data or a significant pregnancy loss in the dairy industry in Sri Lanka. Without specific data pertaining to the exact number of inseminations performed by individual technicians, conception rates, pregnancy rates, pregnancy per AI, and calving rates, improvements are difficult to achieve. Individual farmers did not have records pertaining to these criteria, which would significantly improve their capacity to increase reproductive performance based on technical assistance, use of estrus synchronization, and cow culling.

Success of AI is dependent on the quality of semen to be used for breeding. Although semen is readily available through government subsidy, the quality of this semen in most instances is unknown. A concerted effort is required to evaluate semen at collection and post-thaw to ensure that semen being used is of the highest quality. Poor-quality semen or inadequate freezing procedures are never overcome by the best AI technician. On several occasions, farmers raised concern that the choice of sire pertaining to productivity or breed was not provided.

The success of AI in the dairy industry requires precise timing between observation of estrus and the application of semen. Logistical limitations exist in Sri Lanka between the observation of heat and timely insemination based on the distances between farms and conditions for timely arrival of technicians. An absolute adherence to the AM/PM rule must be established to facilitate success of AI; insemination is required within 12 h of observable heat. If a window of fertility is missed, then the success of AI is significantly compromised (Hall et al., 1959).

Due to inadequate nutrition, the potential for cows to remain in postpartum anestrus is very high. We found no evidence that farmers knew the cyclicity of their own cows. Although cows are unlikely to show signs of heat in anestrus, lack of ovarian function will dramatically increase the calving-to-conception interval in cows. Several potential missed opportunities exist for improvement of reproductive performance based on suboptimal facilities for the detection of estrus. We found no clear information on the protocols implemented by veterinary staff for estrus synchronization. The application of estrus synchronization is extremely time-dependent and requires precise application of drugs to allow exact timing of ovulation and subsequent insemination; however, information on how protocols for estrus synchronization were implemented was nonexistent.

Milk Quality. Lack of national standards consistent with international milk quality standards is perhaps the most significant challenge to improvement of milk quality and increased consumption of fresh milk in Sri Lanka, because regulations are not in place and standards set by processors are subject to change. In

addition, motivating farmers to produce higher-quality milk is a challenge, as most of the milk is aggregated at collection centers before it can be tested at milk cooling centers. Consequently, any ability to apply incentives or disincentives for milk quality to individual farmers is difficult and will only be applicable for producers that ship directly to the processor or cooling center. This challenge applies to SCC, bacteria count, milk components, adulteration, and antibiotic contamination. Whereas most processors claim to have milk with low SCC, data to substantiate this claim is lacking, and claims are questionable, given the conditions where most cows are kept and milked (Figure 2). The distance traveled from a farm to the cooling center can be up to 15 to 20 km. Because most farms have just a few cows and produce <20 L of total milk, cooling equipment for the individual farm is not practical, and, as a result, milk is not cooled for 3 to 4 h after milking, which leads to high bacterial counts ($>5 \times 10^6$ cfu/mL) and some degree of spoilage.

Knowledge for proper identification of mastitis and milking routine protocols is limited. Lack of standards for use of antibiotics, regulations for withholding milk,

and testing for antibiotic residues severely limits the ability to produce high-quality milk (i.e., SCC <200,000 cells/mL) free of contaminants. Diagnostic facilities for proper identification of mastitis pathogens are also lacking, which is critical for controlling contagious mastitis outbreaks.

Routine checks of milking system vacuum and pulsator function are critical for teat health and proper milk harvest; however, resources for proper care and maintenance of milking machines and equipment is limited. The lack of proper training and resources to maintain equipment was evident, as some farmers claimed they quit using milking machines because they could do better by hand-milking, which indicates a lack of proper training and resources to maintain equipment. Equipment suppliers in the US and Europe typically provide maintenance and repairs of equipment for dairy farmers, but because the market is small in Sri Lanka, resources provided by equipment dealers and availability of trained technicians are limited, and significant improper use and malfunction of equipment occur.

Extension Services. The efficacy of extension services is limited, as the extension programming is not a well-coordinated effort among government, university, and industry participants. Veterinarians, along with livestock development officers, AI technicians, and milk collection agents, assist with extension programming to enhance farmer knowledge and skills for improving milk production; however, the extension services provided are not adequate nor fully effective. The ineffectiveness of extension programs is attributed to delivery methods that are outdated and too narrowly approached. In addition, programing methodologies tend toward a “data dump” style rather than facilitative delivery of interactive curriculum that stimulates the application of the knowledge by producers. Furthermore, no tools are available for extension program evaluation, and overall understanding of extension program development and evaluation is limited. Measurement of how well participants have increased their learning as a result of training is lacking. Also, evaluation of extension services based on adoption of improved practices and subsequent improvement in production performance is limited, which leads to lack of accountability among extension agents for training.

Dairy Cattle Management. The genetic potential of imported, high-yield dairy cows is not being realized in Sri Lanka, primarily due to poor husbandry and feeding practices. Little emphasis is given to feeding and managing calves and heifers, and poor feeding regimens lead to suboptimal growth rates and lower feed efficiency (Figure 3). We observed a lack of understanding among many farmers regarding the high costs associated with poor management of young stock,

Figure 2. Clots and flakes left after passing milk through strainer, suggesting lower quality of milk collected from dairy cows suffering from mastitis.

Figure 3. Overcrowding and suboptimal BCS of lactating cows was evident at several dairy farms in Sri Lanka.

which arise due to poor health, high calf mortality, and the subsequent effects on potential milk yields and fertility. In addition, guidelines on managing dry cows were found to be extremely limited.

Cow comfort is paramount not only from an animal welfare perspective but also to improve dairy cattle productivity and profitability of farm operations. We observed limited understanding among farmers about the correlation between cow comfort and animal productivity. Facilities with adequate heat stress abatement, proper bedding material, and proper sanitation and manure disposal were lacking.

Record keeping is a necessary element of good livestock business management. Good records help in analyzing feeding costs and benefits from animal product outputs and assist with economic strategies to optimize production. However, farm records for milking, AI, feeding programs, calving, calf and heifer growth, and animal health are not kept by most of the farmers in Sri Lanka. Also, the concept of cost-benefit analysis in decision making is lacking regardless of the farm size.

Finance and Investment. A need exists for improving the accessibility of financial services so that potential farmers are encouraged to join the dairy sector. The government of Sri Lanka implemented Commercial Scale Dairy Development Loan Scheme; however, more efforts are needed to make sure this scheme is fully utilized. The MOD must work directly with financial institutions to better utilize the government's loan scheme and encourage lending to the dairy sector in general. In addition, technical assistance from the MOD with business plan development as well as assistance with other aspects of dairy production will enable farmers to prepare strong business plans and loan applications and will enable banks to offer new loan products toward dairy sector development. Need exists for greater investment in collection centers, chilling tanks, milking equipment, cattle sheds, milk testing equipment, and more. In addition, the role of private sector companies

and individuals interested in expanding dairy production should be explored.

Market Access. Informal milk supply, the sale of raw milk or traditional dairy products directly to consumers, contributes to the significant amount of locally produced milk. The dairy products sold on the informal market include primarily liquid milk and traditional, locally processed products such as curd. Milk sold via the informal market is not subjected to any treatment to ensure quality or safety standards, and it is the responsibility of the purchasing household to boil the milk before consumption. A need exists to connect informal producers with the formal market, while building demand for quality, safe milk locally so that producers are incentivized to adopt improved practices.

Implementing Recommendations Through Training

Training modules were developed with an objective to improve the capacity of extension agents and extension providers at dairy companies, training public and private AI providers, and training dairy farmers in dairy farming as a business. The progress expected from these training modules included new hectares of land under improved techniques and technologies, enhanced skills of dairy farmers, extension agents receiving training and in turn applying improved farm techniques and technologies. The MOD team is quantifying these indicators and comparing them with the targets established at the end of the project (Table 3).

Milk Production. Three training of trainers classroom sessions on best practices in dairy management were conducted by technical experts from the University of Florida. Sixty-two trainers, including 17 Provincial DAPH veterinary surgeons, 22 Provincial DAPH livestock development instructors, and 23 private extension officers, were trained on best practices for improving the productivity of dairy farmers. The curriculum covered nutrition, fodder production, livestock health and vaccinations, heat detection, management during pregnancy, calf management, estrous synchronization, and other animal husbandry operations for enhancing the productivity of dairy animals. In addition, University of Florida trainers worked with feed samples to raise awareness of feed types, quality, and composition, as well as the practice of testing milk quality to detect SCC. The in-class training was accompanied by a visit to a demonstration dairy farm to apply the concepts learned during classroom training with the field application. Additional training on extension development was provided for 6 DAPH provincial directors, senior managers from 5 dairy processors, and faculty members from the University of Peradeniya, to highlight the collaborative nature of successful extension and to develop

Table 3. Current and projected progress on various performance indicators under the Market-Oriented Dairy project in Sri Lanka

Activity	Performance indicator	Disaggregation	Baseline	Targets ¹					Life of project
				Year 1	Year 2	Year 3	Year 4	Year 5	
Capacity building: Agricultural extension agents/services	Number of hectares of land under improved techniques or technologies as a result of USDA assistance	Total	0	0	706	848	1,817	496	5,506
		New	0	0	706	372	363	99	2,555
		Continuing	0	0	0	476	1,454	396	2,951
	Number of individuals benefiting directly from USDA-funded interventions	Total	0	199	4,110	7,892	14,168	15,184	15,184
		Male	0	154	3,083	5,906	12,043	12,906	12,906
		Female	0	45	1,027	1,986	2,125	2,278	2,278
		New	0	199	3,911	3,782	9,240	3,850	3,850
		Continuing	0	0	199	4,110	4,928	11,334	11,334
		Total	0	576	12,330	23,676	42,504	45,553	45,553
	Number of individuals benefiting indirectly from USDA-funded interventions	Total	0	0	1,038	1,769	1,440	360	4,320
Inputs: Develop agrodealers and other input suppliers	Number of individuals who have applied improved farm management practices (i.e., governance, administration, or financial management) as a result of USDA assistance	Total	0	0	779	1,327	1,224	306	3,672
		Male	0	0	259	442	216	54	648
		Female	0	0	0	0	0	0	0
	Number of individuals who have applied new techniques or technologies as a result of USDA assistance	Total	0	0	1,233	2,520	3,960	4,320	11,880
		Male	0	0	922	2,142	3,366	3,672	10,098
		Female	0	0	311	378	594	648	1,782
		New	0	0	1,233	1,656	1,944	1,152	5,832
		Continuing	0	0	0	864	2,016	3,168	6,048
	Number of individuals who have received short-term agricultural sector productivity or food security training as a result of USDA assistance	Total	0	80	2,304	1,800	1,800	450	5,400
		Male	0	50	1,738	1,530	1,530	382	4,590
Inputs: Develop agrodealers and other input suppliers	Value of sales by project beneficiaries (US\$)	Total	0	0	2,304	720	360	90	810
	Volume of commodities (t) sold by project beneficiaries	Total	0	0	0	1,080	1,440	360	2,880
	Number of private enterprises, producers organizations, water users associations, women's groups, trade and business associations, and community-based organizations that applied improved techniques and technologies as result of USDA assistance	Total	15,427,539	17,786,887	26,942,882	33,523,072	35,168,119	35,168,119	35,168,119
		Total	38,525	38,525	41,543	67,281	83,712	87,820	87,820
	Number of public and private extension agents' skills enhanced to provide recommendations on best practices for animal health and productivity	Total	0	0	26	19	0	0	54
		New	0	0	26	19	0	0	54
		Continuing	0	0	0	35	54	54	143
	Number of dairy input retail operations established	Total	0	0	19	5	6	3	18
		Total	0	0	19	5	6	3	18
		Male	0	89	586	350	300	50	900
		Female	0	78	498	298	255	42	765
Activity 1—Capacity building: Agricultural extension agents/services	Number of individuals benefiting directly from USDA-funded interventions	Total	0	199	4,110	7,892	14,168	15,184	15,184
		Male	0	154	3,083	5,906	12,043	12,906	12,906
		Female	0	45	1,027	1,986	2,125	2,278	2,278
		New	0	199	3,911	3,782	9,240	3,850	3,850
		Continuing	0	0	199	4,110	4,928	11,334	11,334
		Total	0	576	12,330	23,676	42,504	45,553	45,553
	Number of individuals benefiting indirectly from USDA-funded interventions	Total	0	0	1,038	1,769	1,440	360	4,320
		Male	0	0	779	1,327	1,224	306	3,672
		Female	0	0	259	442	216	54	648
	Number of individuals who have applied new techniques or technologies as a result of USDA assistance	Total	0	0	1,233	2,520	3,960	4,320	11,880
Activity 2—Inputs: Develop agrodealers and other input suppliers	Value of sales by project beneficiaries (US\$)	Total	0	0	2,304	720	360	90	810
	Volume of commodities (t) sold by project beneficiaries	Total	0	0	0	1,080	1,440	360	2,880
	Number of private enterprises, producers organizations, water users associations, women's groups, trade and business associations, and community-based organizations that applied improved techniques and technologies as result of USDA assistance	Total	15,427,539	17,786,887	26,942,882	33,523,072	35,168,119	35,168,119	35,168,119
		Total	38,525	38,525	41,543	67,281	83,712	87,820	87,820
	Number of public and private extension agents' skills enhanced to provide recommendations on best practices for animal health and productivity	Total	0	0	26	19	0	0	54
		New	0	0	26	19	0	0	54
		Continuing	0	0	0	35	54	54	143
	Number of dairy input retail operations established	Total	0	0	19	5	6	3	18
		Total	0	0	19	5	6	3	18
		Male	0	89	586	350	300	50	900
		Female	0	78	498	298	255	42	765

Continued

Table 3 (Continued). Current and projected progress on various performance indicators under the Market-Oriented Dairy project in Sri Lanka

Activity	Performance indicator	Indicators							Life of project
		Disaggregation	Baseline	Year 1	Year 2	Year 3	Year 4	Year 5	
Activity 5—Training: Sanitary and phytosanitary standards Financial services: Leverage private and public investment	Percent of beneficiary farmers earning higher prices than before start of project interventions, due to improved milk quality	Total (%)	0	0	19	50	70	80	80
	Number of individuals receiving financial services as a result of USDA assistance	Total	0	0	1,312	1,360	900	225	2,700
		Male	0	0	1,076	1,010	765	191	2,295
		Female	0	0	236	350	135	34	405
	Number of jobs attributed to USDA assistance	Total	0	0	20	38	75	75	200
		Male	0	0	15	29	64	64	170
		Female	0	0	5	9	11	11	30
	Number of loans disbursed as a result of USDA assistance	Total	0	0	55	379	720	180	2,160
	Number of public-private partnerships formed as a result of USDA assistance	Total	0	9	11	4	0	0	10
	Total increase in installed storage capacity (dry or cold storage) as a result of USDA assistance	Total	0	0	58	212	18	4	54
Market access: Facilitate buyer-seller relationships		Dry	0	0	44	173	5	1	14
		Cold	0	0	14	39	13	3	40
	Refurbished		0	0	7	117	0	0	0
	New		0	0	51	95	18	4	54
	Total		0	0	256,667	397,954	1,700,000	800,000	5,600,000
	Value of loans provided as a result of USDA assistance (US\$)	Male	0	0	192,500	298,466	1,445,000	680,000	4,760,000
		Female	0	0	64,167	99,488	255,000	120,000	840,000
	Value of new public and private sector investment leveraged as a result of USDA assistance (US\$)	Total	0	0	1,257,827	2,712,808	4,550,000	1,750,000	24,150,000
		Public	0	0	0	0	0	0	0
		Private	0	0	1,257,827	2,712,808	4,550,000	1,750,000	24,150,000

¹Year 1: 10/1/2017–09/30/2018. Year 2: 10/1/2018–09/30/2019. Year 3: 10/1/2019–09/30/2020. Year 4: 10/1/2020–09/30/2021. Year 5: 10/1/2021–09/30/2022.

a consensus on the importance of the government, the private sector, and academia working together.

Building upon the University of Florida training modules, the MOD team developed farmer-friendly training modules focused on best practices in dairy management in local languages (Tamil and Sinhalese). The training material has been rolled out at MOD demonstration farms to 1,324 farmers supplying milk to 7 different processors across 13 districts, and consisted of classroom-type presentations with training materials, on-site practical observations, and hands-on training. Thus far, 153 farmers have been trained in best practices in fodder production and silage making, and another 581 public and private sector extension agents' skills have been enhanced via training. Based on the evaluation report, most dairy farmer participants have found trainings relevant and applicable.

The concept of nutrient-balanced diet formulation is totally lacking, resulting in inadequate levels of nutrients supplied to the dairy cows. The MOD team, in collaboration with the University of Florida, have proposed use of a mobile-based application for ration formulation. This application will provide users with a set of feed ingredients for cattle that will fulfill the nutrient requirements of the animals and help them reach their highest genetic and milk-producing potential. The feed formulation app will seek to optimize the combination of locally available feed resources to meet nutrient requirements of animals on a least-cost basis. The nutrient database will be prepared by testing feed ingredients at the University of Peradeniya. Samples will be collected from different provinces, to obtain more representative nutritional values for the ration formulation app.

The lack of adequate quantity and quality of forages year-round compromises well-balanced nutrition for the dairy cows. Although some farmers have enough land and can produce forage for their operations, others are constrained by lack of either irrigation facilities or available land. The activities of the MOD project have supported development of at least 4 fodder and silage enterprises to meet the fodder and silage needs of farmers in each target region. The establishment of fodder and silage enterprises will sustainably address one of the largest constraints for dairy farmers in Sri Lanka.

AI and Reproduction. The training module on improving AI services was focused on improving the capacity, delivery, and success of AI services in Sri Lanka. The technical experts from the University of Florida conducted 3 training sessions and 2 refresher trainings for 89 participants, consisting of currently practicing livestock development instructors and AI technicians, including both public- and private-sector employees. Additionally, a 2-d intensive training of trainers was

also conducted with 13 national AI trainers, including veterinarians nominated by provincial DAPH directors. The goal was to train provincial-level veterinarians so that they can mentor and provide advice to AI technicians in their respective regions. The topics covered during AI trainings included female anatomy review, protocols of synchronization, AI principles, and endocrinology of the estrous cycle. The feedback from trainees was positive, and more interest was generated among other provincial DAPH offices, the National Livestock Development Board, and large private farms to receive this training. The technical experts from Texas A&M University conducted another 6 refresher trainings for 296 technicians from DAPH, technicians from large farms, and private technicians. Training sessions included 17 AI technicians from 6 large dairy farms, 209 livestock development instructors from DAPH, and 70 private AI technicians.

Milk Quality. The focus of the training programs was to improve the quality and safety of milk produced through training farmers and collection center managers, to increase the demand for safe milk at the local level, and to introduce market-based incentives based on quality standards. Training modules developed at the University of Florida were used to train 62 trainers on best practices in improving milk quality. Three training of trainers sessions over a span of 3 d were used to train 17 veterinary surgeons, 22 DAPH livestock development instructors, and 23 private extension officers. Additional training sessions were provided by technical experts from the University of Florida to 56 employees of dairy companies that are members of the All Island Dairy Association. The trainings were focused on the importance and definition of milk quality, best management practices in safe handling of milk, milk equipment cleaning and maintenance, and tests for milk quality. Based on these training modules, the MOD team developed farmer-friendly training modules in the Sinhalese and Tamil languages, focused on best practices in milk quality, and piloted that training for 25 dairy farmers. The training was well received, and it was suggested that an audit be conducted at each chilling center based on practices introduced at the training. The MOD team plan on working with trained chilling center managers in conducting further farmer training on milk quality improvements. The training program from the MOD team was prioritized for farms producing over 60 L per day. To date, 30% of the project's total number of targeted farmers (5,400) have experienced improvement in milk quality due to MOD interventions and recommendations.

Milk quality is also addressed and improved after milk leaves the farm by improving best practices by transporters and at milk collection centers. The training

program for collection agents included the importance of personal hygiene, checking and accepting only good-quality milk, immediate chilling of milk after collection to reduce bacterial growth, managing the milk chilling equipment, fairness in assessing supplier milk quality, appropriate payment, and overall motivating others to practice good protocols. So far, MOD has facilitated the use of 39 m³ of newly installed cold storage valued at US\$631,333 to improve milk chilling capacity.

Quality-based payments for milk producers are essential to promote best management practices and achieve better milk quality. At present, milk quality is commonly associated with components such as milk fat and solids-not-fat; however, milk quality is related to SCC and bacterial counts, and MOD is working toward raising milk-quality awareness through trainings.

Extension Services. The effectiveness of extension services for dairy producers remains a challenge in Sri Lanka. Improved extension services can not only improve knowledge and awareness but also improve adoption rates of best management practices among dairy producers. The use of mobile extension services was proposed, to improve the effectiveness of the extension program. Recently, MOD has partnered with the government of Sri Lanka and Dialog, a major mobile carrier, to launch “Saviya,” a mobile-based advisory service for dairy farmers. The service was developed based on an existing mobile extension service, called “Govi Mithuru” (in Sinhalese) or “Uzhuvar Tholan” (in Tamil), used for providing crop-specific information to farmers. The MOD team has incorporated additional automated messages focused on dairy production, importance of milk quality, and fodder and silage production, on this platform. The mobile extension service will complement existing extension efforts by the national DAPH, provincial DAPH, and processing companies, enabling broader and more frequent reach to dairy producers in a cost-effective way. The mobile extension platform has 4,006 active users, of which 46% are farmers selected by MOD. From the recent survey, 100% of active users found this service useful.

Dairy Cattle Management. Best practices for improved record keeping, calf management, dry cow management, heat stress abatement, and other animal husbandry management methods enhance productivity of dairy animals. The training method for promoting best practices has moved away from traditional approaches to a self-realization training method. Farmers are first asked a series of pertinent questions, and then they are engaged in discussion around their answers and the benefits of changing their dairy farming practices. Lastly, they are presented with practical solutions to the challenges they identified through the questions. The technical trainings on dairy management are held

at demonstration farms, where farmers can see first-hand best practices in daily management at farms. The MOD team is currently working at 42 demonstration farms and has identified 19 of them to receive MOD-funded strategic investments to upgrade farm operations. The investments can be used to improve cattle sheds, calf pens, barrels for silage, cutters for chopping fodder, and irrigation equipment. For cow comfort, the MOD team contracted a local engineering consultant to design and improve upon existing cattle shed designs so as to make a loose-housing-style barn, adequate for 10 animals, and to provide technical assistance in remodeling and building these as needed.

Financial Services. Activity focused on financial services is aimed at increasing investment in Sri Lanka’s dairy sector, both through the establishment of an investment fund and by aiding financial institutions to encourage lending in the dairy sector. The International Executive Service Corps has awarded a subrecipient agreement to the Small Enterprise Assistance Fund to stimulate investment in inputs and improvements in dairy productivity and quality across the value chain. Led by the Small Enterprise Assistance Fund in close collaboration with the Investment and Finance Director, this activity aims to increase access and availability of debt and equity financing and to encourage additional investments in the dairy sector.

The MOD team is also working to improve banks’ and other financial institutions’ understanding of the needs and opportunities of the dairy sector, to assist in the development of new financial products to meet the needs of the dairy sector, and to improve potential dairy sector borrowers’ abilities to develop business plans and manage finances. By the end of second year, MOD has encouraged, supported, and leveraged \$3,970,634 in investments to the dairy sector, increased cold and dry storage capacity by 270 m³, and created 58 jobs.

Market Access. The objective of market access activity is to facilitate relationships between buyers and sellers of inputs in the dairy sector, as well as to develop market linkages for dairy farmers seeking to move from the informal sector to the formal sector. The MOD is working with companies such as Fonterra, MILCO, Nestle, CIC, Richi, Richlife, Ruwansiri, Pelwatte, Chello, Polonnaruwa Coop, and Wonrich, who are seeking to expand their supply of milk and are willing to expand their catchment areas. Existing organizational structures and training facilities will be leveraged by MOD, to avoid duplicating existing resources. The MOD is training and linking informal small-scale producers with value chain stakeholders such as input service and product providers, and milk buyers such as dairy processors. As a part of the MOD project, a mobile application is being planned, to link

buyers and sellers of cattle, as well as producers and procurers of AI services. The first function of the app will address the constraints many farmers face in procuring livestock for their dairy farms when they need to replace cattle or expand their businesses. This feature of the app will allow users to browse for sellers of cattle (by breed and location) or advertise cattle for sale. The second function of the app will allow a farmer to send out a request for AI services immediately upon identifying a cow in heat.

Farmer Selection. Target farmers ($n = 1,725$) were identified based on farmer selection criteria. The MOD team, in close collaboration with dairy processors, organized and hosted 5 farmer orientations (total of 311 farmers) to raise awareness about the project, gauge farmer interest and commitment, and collect initial baseline farm information. The MOD team identified and selected 24 demonstration farms, which have been used to host trainings and provide demonstrations on best practices in dairy farm management, animal husbandry and wellbeing, and milk quality and hygiene. Dairy processing companies were involved in the selection process and evaluation of upgrades and technical assistance needed on the demonstration farms.

Key Findings. Although the MOD project is still ongoing and is in its third year, we have started observing positive outcomes attributed to project activities planned and conducted in its first years. Dairy farmers associated with MOD sold 41,543 t of milk valued at \$17.8 million in the second year, whereas 32,107 t of milk valued at \$17.0 million were sold in the first 6 mo of the third year. So far, MOD has established 42 demonstration farms and trained 4,940 dairy farmers, with 90% of trained farmers adopting technical best practices on their farms. In addition, 1,162 technical and business trainers and extensionists have been trained from both the public sector (DAPH) and the private sector (dairy processors). Along with dairy farmers, 330 fodder producers and buyers have also been trained, with 95% adopting best cultivation practices. This has resulted in 848 ha of fodder cultivated under improved practices. Additionally, 5 silage enterprises have been established with technical assistance from MOD activities. Some of the MOD activities not discussed in this manuscript included leveraging public and private investment to improve investment in Sri Lanka's dairy sector. To date, MOD has leveraged \$4.0 million in investments in the dairy sector, increased cold and dry storage capacity by 270 m³, and created 58 jobs. Banks have started showing interest in dairy projects, and 4 banks are now working with MOD in trainings. Thus far, 2,672 farmers have received financial services, and MOD has facilitated 434 loans valued at \$654,621.

Success Stories: Adoption of Best Management Practices by Farmers

Quick learning and early adoption of best practices were shown by some farmers in the Central Region of Sri Lanka, identified by the MOD team while carrying out the needs assessment survey. For example, one family of early adopters own a herd of 7 cows (4 in first lactation and 3 dry cows), 2 heifers, and 7 calves. The total milk production at the time of the assessment survey was 20 L/d, with 4 to 5 L/d average production per cow, and cows were milked once per day. Cows were raised on free grazing, with 1 kg/d of concentrate feed (Dhal powder) and 2 kg of rice polish.

The experts from the MOD team shared basic guidelines on improving milk production through better nutrition, adequate water availability, and alleviation of heat stress by cooling cows, and recommended twice-daily milking. The family followed this advice and ensured water availability, and, instead of depending solely on free grazing, they started providing 30 kg of fodder twice a day, along with increasing the concentrates to 3 kg of dhal powder and 3 kg of rice polish per day. In addition, animals were given showers 3 times a day to alleviate heat stress. Improved nutrition and better cow comfort resulted in 30 to 32 L/d total milk production, a 60% increase, by adopting very basic best practices. Because of greater milk production, the family is getting additional income of LKR 25,000 to 30,000 per month (US\$133–160), and they are looking forward to further enhancing their knowledge through the MOD Dairy Entrepreneur Development Program.

Similarly, another dairy farmer was practicing semi-intensive management with a total of 40 animals. The animals were grazed in the available land and forest during the day, and at night they were brought into a cattle shed. Under this system, the farmer had problems finding pasture land to feed the animals, and letting the cows lose in government reservations was illegal. In addition, these animals did not have access to water while grazing in the forest land.

The experts from the MOD team shared key action points to increase productivity by gradually working toward an ideal herd composition and by providing adequate feed for the animals based on their body condition. Based on these guidelines, the farmer agreed to reduce the total number of animals from 40 to 25 and to improve the quality of feed offered to the remaining animals. Unproductive animals were sold, and the money was used to improve the existing cattle shed, effluent management system, and calf management. The cattle shed floor was redone to ensure a proper gradient for cleaning. With fewer animals, more space

per animal was available in the shed, and the farmer switched from semi-intensive to intensive management for milking the animals. Animals were fed a TMR-based diet. Calf management was improved, as calves were kept in a separate calf shed. Despite lowering the herd size, total milk production stayed the same (65–70 L), resulting in a 60% increase in productivity. This farmer is now establishing his farm as a model farm, and he is appreciative of the change in mindset to unlearn poor habits and relearn best practices to create a profitable business. Because of positive experiences, his daughter has also joined her father in the dairy enterprise and is keen to learn and continue the family legacy. The goals of their dairy enterprise are now clearly defined, with short-term goals of having the correct herd size, growing more feed crops, making silage to ensure feed availability throughout the year, and improving hygienic milking practices and calf management. In the medium term, they are looking at improving the biosecurity measures of the farm and maintaining a proper record-keeping system. The family is eager to enhance their farm management practices through continued engagement with the MOD team and to share these best practices by molding the farm into a demonstration unit, to support training activities in the region.

CONCLUSIONS

The 4.5-year, USDA-funded MOD project is designed to catalyze sustainable growth in Sri Lanka's dairy sector by supporting farmers and enterprises to meet increased demand for dairy products. This project is building a systemic foundation for the growth of the dairy industry by building the capacity of 15,184 individuals to increase the milk production of participating farmers and farms, at an annual growth rate of 18%, to a total of 87,820 t by 2022. In addition, the project will ensure that 80% of beneficiary farmers will earn a price premium due to improved milk quality. The need for greater investment in the dairy sector is being addressed with MOD both through the establishment of investment funds and by providing assistance to financial institutions to encourage lending in the dairy sector. Additionally, MOD is facilitating relationships between buyers and sellers of inputs in the dairy sector, as well as developing market linkages for dairy farmers seeking to move from the informal to the formal sector. The activities underway in this project are designed to address identified weaknesses in the dairy value chain and catalyze changes to address those weaknesses in a manner leading to lasting sustainability for the dairy sector. Although the MOD project is still ongoing, based on preliminary M&E reports, this project has trained 4,855 individuals, with 90% of dairy farmers

adopting technical best practices on the farm. The effects of various interventions are resulting in greater milk production among participating producers, as dairy farmers have sold 41,573 t of milk valued at \$17.8 million in year 2 of this project, and 32,107 t of milk has been sold in the first 6 mo of year 3.

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Appendix 1

The Market-Oriented Dairy (MOD) project's methodology to carry out surveys and the process used to collect, record, and maintain data on project indicators (adapted from the MOD team).

International Executive Service Corps MOD designed and put in place a set of data collection practices and analytical methodologies to meet USDA periodic reporting requirements. There are 22 MOD program performance indicators with set annual targets, and MOD agreed to report each of them on a 6-mo periodic basis.

To report on performance indicators, various data sources and different methodologies are used to collect data in order to capture and report on results. The following are the different sources for data.

1. International Executive Service Corps MOD contracted Survey Research Lanka Pvt. Ltd. to conduct periodic (6-mo basis) field surveys (semi-annual beneficiary survey) to interview dairy farmers who have engaged in MOD technical interventions, to analyze their dairy operations and performance. These dairy farmers are direct beneficiaries of the MOD program.

Technical staff of MOD is directly involved in designing the survey questionnaire, field monitoring and technical assistance, training enumerators, data verification, and overseeing quality assurance processes. Both Survey Research Lanka supervisors and the MOD monitoring and evaluation (M&E) team randomly check completed survey questionnaires via a random revisit of a small sample of respondents. Based on the analyzed data presented to and verified by the MOD M&E team, the data will be reported to the USDA. The survey provides partial or all information for 9 of the 22 indicators (Indicators 1, 4, 5, 10, 11, 13, 14, 16, and 21).

2. Details about the direct beneficiary who has undergone MOD trainings, seminars, workshops, and conferences, such as dairy farmers, commercial fodder cultivators, input retailers, private sector extension agents, public vets, public livestock development instructors, AI technicians, MOD trainers, and All Island Dairy Association members are collected through completed and signed attendance sheets. Hard copies of attendance sheets with gender-segregated data and signatures confirming participation in training events are kept in the MOD head office, and data are entered into the database by 2 data entry operators. This data provides partial or all information for 5 of the 22 indicators (Indicators 2, 3, 6, 9, and 17).

3. A set of field data collection forms have been developed and used by MOD. These 11 forms were developed by the technical team and are filled out by the MOD team in the field. The following data forms are available in English, Tamil, and Sinhalese. In some instances, field staff fill out the hard copy of a form and then it is uploaded in the Colombo office by data entry staff. In other instances, field staff have direct access to the MOD database and thus upload directly from the field into the database. Not all forms are uploaded into the database, but instead Microsoft Excel sheets (Microsoft Corp., Redmond, WA) have been developed to analyze results.

(A) Dairy Farmers: (1) Farmer Assessment form is used as initial farmer profile data sheet; (2) Key Performance Indicator (KPI) form is used to collect the farmer information at the beginning of engagement with farmer and set forth a plan for growth; (3) Dairy Farmer Mentoring and Monitoring (M&M) form is used by field staff to examine the farmer's performance periodically when visiting farms and farmers.

(B) Commercial Fodder Cultivators: (1) Commercial Fodder Cultivators Assessment form is used as initial cultivator profile data sheet; (2) Commercial Fodder Cultivator M&M form is used by field staff to collect data and monitor progress. These forms provide partial or all information for 3 of the 22 indicators (Indicators 1, 4, and 16).

(C) Input Retailers: (1) Action Plan and (2) M&M forms, designed based on the key performance indicator introduced in their input retailer action plan, are cross-checked by field staff and reported to the USDA input retailer's performance-related indicators. This data provides partial or all information for 3 of the 22 indicators (Indicators 15, 16, and 18).

(D) Storage Capacity: Dry Storage Data Collection form is designed to collect the dry storage capacity (e.g., silage) of dairy farmers. Cool storage capacity of the dairy processors is collected via direct contact, with written confirmation by the companies, and reported to the USDA. This data provides partial or all information for 2 of the 22 indicators (Indicators 13 and 16).

(E) Large Farms: (1) Large Farm Assessment form is used as initial profile and for selection purposes, and (2) Large Farm Data Collection form is used to collect their milk production and sales value details and reported to the USDA. This data provides partial or all information for 3 of the 22 indicators (Indicators 7, 8, and 16).

(F) Financial Checklist: Used by field staff to assess the farmer's needs on financial requirements and present investments. This data provides partial or all data for 2 of the 22 indicators (Indicators 9 and 14).

4. Dairy processors' data: The MOD officially requests dairy processing companies to provide dairy farmers data on periodic (6-mo basis) production, value prices, and fat and SNF data. The MOD provides a list of farmers who have participated in technical training from each company separately, and company officers provide the data accordingly. Data are analyzed by the M&E team and reported to the USDA. This data provides partial or all information for 2 of the 22 indicators (Indicators 7 and 8).

5. Dairy processing companies provide information on an ongoing basis about investments in cold storage capacity and number of jobs created. This data provides partial or all information for 3 of the 22 indicators (Indicators 10, 13, and 16).

6. Dairy processing companies provide loan information under the Smallholder Agribusiness Partnerships Program. This data provides partial or all information for 3 of the 22 indicators (Indicators 9, 11, and 14).

7. The MOD uses officially signed memoranda of understanding to report to the USDA on the indicator of number of private-public partnerships developed. This data provides information for 1 of the 22 indicators (Indicator 12).

8. Dialog, the partner who implemented the Saviya program, is contacted periodically to assess the Saviya dairy program phone SMS users. This is used to inform the indicator on the number of Saviya users registered. This data provides information for 1 of the 22 indicators (Indicator 20).

9. The All Island Dairy Association is contacted to determine their number of paid members for USDA reporting. This data provides information for 1 of the 22 indicators (Indicator 22).

10. The MOD Investment Fund is implemented by Small Enterprise Assistance Funds, which will provide supporting documentation to verify debt and equity investments placed. This data provides information for 1 of the 22 indicators (Indicator 19).

11. Additional survey: The MOD implements the supportive Dairy Farmer Field Survey to examine the other reporting parameters, such as informal market values of dairy products and farmers' knowledge of dairy. This data provides partial or all information for 2 of the 22 indicators (Indicators 7 and 8).

Note: Not all information collected and analyzed is used only for USDA reporting requirements; it is also used for program management, to understand how interventions are resulting in changes in behavior and practices. Along with a local developer, MOD custom-built a Management Information System database. The MOD maintains this database with 2 data entry operators, and hard copies are mostly held in the head office in Colombo.