



Advisory Report

Family Dairy Tech, India

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Colophon

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This report describes the results and recommendations for Indian dairy farmers and Dutch and Indian companies, from the RAAK Family Dairy Tech India project. Researchers and students of two Dutch and one Indian University of Applied Sciences, together with ten Dutch companies, Indian companies and eight innovative farmers in Pune district collaborated to develop robust and affordable technologies and knowledge for Indian medium sized dairy farmers, in Pune district, Maharashtra. The report also describes innovations in the farmers' business models and value chains.

Key words: family farmers, Indian dairy, frugal innovation, dairy farming

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Editing: Jesse Versteegh

Many students, researchers, entrepreneurs, farmers contributed to this project. They are mentioned under 'Contributors' at the end of this report.

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Preface

This report is the result of two years of applied research of three Universities of Applied Sciences, in the Netherlands (Van hall Larenstein and Saxion) and India (College of Agriculture, Baramati). In the project we studied how Dutch knowledge and Technology on Dairy farming could benefit medium sized dairy farmers in Pune district, Maharashtra. Between September 2015 and September 2017 we collaborated with ten Dutch companies, Indian companies and farmers to analyze their situation, needs and potential and designed new technology and knowledge that could help farmers on all aspects of their dairy farm management. Regular feedback from farmers and companies made the research a genuine example of an action research approach. This report summarizes the advices from the project to famers and entrepreneurs.

We wish to thank our Indian colleagues from Agricultural Development Trust, Baramati and notably its Chairman, Hon. Rajendra Pawar, prof. Nilesh Nalawade and Dr. Dhananjay Bhoite for the valuable and friendly collaboration and great hospitality. The participating farmers for receiving us with great hospitality on their farms, sharing all their information and actively participating in workshops. Indian feed companies and dairy processors, Baramati Agro, Yash Dairy, Schreiber-Dynamix and Nandan Cooperative received us during our 'learning journeys' at their plants, shared information and provided advice.

Many Indian and Dutch students, researchers, supporting staff and entrepreneurs turned this project into a rewarding experience and contributed to the results. They can all be found in the colophon in this report. We thank Mr Sritanu Chatterjee from the Dutch Consulate, Mumbai, for his advice and support.

Last but not least we want to thank the SIA-RAAK foundation for financing and notably its staff, Rolf Bossert and Lex Sanou for 'coaching' the project in a constructive way.

Rik Eweg

Velp, 19 September, 2017



Summary

This advisory report describes the results and recommendations for Indian dairy farmers and Dutch and Indian companies, from the RAAK Family Dairy Tech India project. Researchers and students of two Dutch and one Indian University of Applied Sciences, together with ten Dutch companies, Indian companies and eight innovative farmers in Pune district collaborated to develop robust and affordable technologies and knowledge for Indian medium sized dairy farmers, in Pune district, Maharashtra. The report also describes innovations in the farmers' business models and value chains.

Innovations in barn design focus on reducing heat stress of cows. Above 27°C a cow goes into a mild heat stress and will not lay down. Each hour a cow is standing instead of lying could cost one litre reduction in milk production. Nine factors causing heat stress are identified. The project focused on improving ventilation and roofing, other ways to improve cow cooling and on better barn design. Alternative roofing materials that are suitable for barns in the Pune district are: insulated sandwich structures made of fiberglass or aluminium sheet with polystyrene foam, composite materials and canvas materials. Twelve features for a design of a new barn "2.0" are specified. In the end, a complete innovative design "3.0" for a next generation of sustainable barns is presented.

The recommendation for innovation in feed and silage is to introduce maize silage, produced and sold in bales. This can be introduced by demonstrations, feed trials, information leaflets or instructive posters and videos of success stories. Introducing silage as a profitable feed system makes better quality of feed available during the whole year, leading to a more constant good quality milk flow. The main risk will be availability of land and the competition between land use for cattle feed and human food production. Apart from social, economic and political factors the availability of water resources, land use and top soil management practices are important factors.

Dairy cattle breeding is all about selecting the best animals producing a superior generation as compared to the parent generation of animals. A method is introduced to start up a milk production recording system for understanding the genetic potential of the herd. Two main innovations are suggested: setting up a Farmer's Dairy Breeding Association (FDBA) and the Uniform Agri App record keeping system. The FDBA system addresses accurate measurement and improvement of animal performance on individual farm level. The Uniform Agri App system supports chain actors as dairy processors to stimulate farmers using data in their farm management. A combination of both systems is likely to be a good way to motivate the directly involved parties: farmers, local processing industry and AI service organisations.

For innovations in support of dairy farm management, the method of 'cause effect diagrams' are described to analyse the problems faced by the farmers. It is expected that advisory services of KVK or private companies will support farm managers in implementation of the cause-effect diagram method. First of all, advisors and innovative farmers have to be trained to implement this system.

To have sufficient capacity to invest in innovative technologies, value chains and business models of the farmers have to be innovated. These innovations will focus on quality management, new value chains for untouched milk and on short (producer-consumer) chains for 'A1' and 'A2' milk.



Quality management at farm level plays a crucial role in producing high quality of milk. For this, four aspects need full attention: animal healthcare, milking, storage and feeding. It is advised that processors first set an upgraded set of standards for off-farm milk, connected to the international quality requirements for milk secondly, the processor has to set up a system for sample taking, giving feedback to the farmers and implement motivational measures for the farm management and farm workers to maintain the required quality level.

The value chain of untouched milk is described as a unique product “from teat to glass”, retaining the natural state, with high nutritional value in terms of fat, protein and calcium’, not-homogenized. Milk cooling is crucial in this chain. Two types of cooling are discussed: “Village Milking and Cooling System” for a community of smallholder farmers and a chain with Bulk Milk Coolers (BMC) for five smallholders. Besides this, the farmers should install a (bucket) milking machine and a clean milking area.

The value proposition of the A2 chain is “fresh, full fat A2 milk of desi cows”. The chain is coordinated by a private company arranging the collection, processing and distribution of the milk, offering the desi farmers a higher than regular off-farm milk price in order to make strong chain links.

The value proposition of the A1 chain is “fresh, full fat, untouched milk of constant quality, delivered at home freely”. The researchers propose to unlock new customer segments, such as restaurants and industry canteens, stating that “untouched” milk can be sold at a higher price.

Lastly, the report provides an overview of existing products and services of the Dutch companies participating in the RAAK project, that were rated as ‘affordable and robust’ for Indian family farmers.

The report concludes with ten advices for Dutch companies that want to explore, enter or expand opportunities for their business on the Indian market of small and medium sized dairy farmers.



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1 Introduction

1.1 Background

India is the leading milk producer in world, producing approximately 19% of the world's total milk, producing around 156 million MT of milk and growing at an annual growth rate of 4% (FASAR & YESBANK, 2016). This milk is produced by 60 million dairy farmers, most of which are small and medium sized family farmers. The urban population growth, increasing income and consumer's awareness, changing lifestyles and increasing expenditure on health influences, leads to a growing market demand. Dutch companies and knowledge institutes have demonstrated knowledge and a wide array of products and services to improve animal housing systems, milk production and milk quality.

As an Indian dairy farmer your most important challenge is to generate a high margin on your milk to generate a decent income for your family. The gravity of this challenge became clear once more during the farmers strike in June 2017, when farmers stopped sending fruit, vegetables and milk to cities, demanding debt relief and higher prices for their products.

Family dairy farmers in Maharashtra operate in a complex network of milk collection agents, cooperatives and milk-unions, private and cooperative processors, feed providers, and retailers. They face cultural values attached to cows and their products, draughts and high temperatures and more strict regulations on animal welfare and animal transports. The farm they manage is an integrated system consisting of many aspects: fodder crops and silage, manure handling, concentrates, cow health, breeding and management, barn construction, milking parlors, milk quality and transport, customer demands and market chains. A project aimed at improving the income and conditions for farmers can not address isolated aspects. A well-shaped cow, will not produce optimally if not fed well or if barn temperatures raise to 35 degrees, a high production of milk is worthless if not handled in a hygienic way, a modern barn construction cannot be realized if the business model of the farmer does not allow the room for investments.

The technology and knowledge of Dutch companies generally focuses on high tech dairy farms with a large investment capacity. Modern dairy farms, with high tech milking technology like carousels can be found in most states in India. However, this technology is no within reach of the millions of family dairy farmers in India. These farmers, who are the backbone of viability of the Indian rural communities and countryside and are close the traditional, often sustainable Indian farming systems need affordable and robust technology. Transforming modern, high-tech technology and knowledge to make it functional for small and medium sized family farmers is known as 'Frugal Innovation', an innovation approach inspired by the Indian 'Jugaad innovation' approach.

In the RAAK Family Dairy Tech India project, researchers and students of two Dutch and one Indian University of Applied Sciences, together with ten Dutch companies, Indian companies and eight innovative farmers in Pune district embarked to 'frugally innovate' Dutch technology and knowledge to make it useful for Indian medium sized dairy farmers.

This advisory report is one of the results of the project. It outlines the advices the project consortium has for the participating farmers and companies how Dutch technology and knowledge could be incorporated. The project and advices are ordered in paragraphs on 'Better farmers and cows', 'Better farmers and markets' and 'Better Housing'.



The comprehensive insight of the project is that innovating the Indian dairy sector is about a process without short term sales or quick investments. It is, in the tradition of Mahatma Gandhi, about 'creating an ecology of change' rather than a quick revolution. Or in scientific terms, about an 'incremental system innovation' rather than radical innovations.

1.2 Dairy farming in India

The Indian dairy sector adds up to 5,3% of the total current GDP of India. This percentage increased rapidly and it is expected that the share of the dairy sector in the GDP will continuously grow. The total employment rate in the Indian dairy sector is around and about 12% in relation to the total employment rate. Around 8.47 million people are employed in India's dairy sector, of which 71% are women. Most family farms are mixed farming systems that combine vegetables, arable farming and livestock.

The increasing population, increasing income and consumer's awareness, changing lifestyles and increasing expenditure on health influences the demand of consumers. About 60% of the milk in India is consumed as milk and about 40% is transformed into various traditional and non-traditional products, such as: ghee, paneer, khoa, curd, (flavoured)yoghurt, butter, buttermilk, lassi, cheese, ice-cream or milk powder.

New processing and post-processing methods on innovative packaging, cold chain and new processing technologies offer new chances for processors and technology and service suppliers.

Table 1:

Major parameters related to milk production in Uttar Pradesh, Andhra Pradesh & Telangana and Maharashtra (FASAR & YES BANK, 2016).

Parameter	Unit	UP	AP%TS	Maharashtra	India
Milk production	Million MT	26.1	14.6	9.7	155.5
Share of indigenous cow milk	%	18%	9%	14%	21%
Avg. yield for indigenous cow	Per animal per kg per day	2.6	2.1	1.8	2.5
Share of cross bred cow milk	%	7%	20%	41%	25%
Avg. yield for cross bred cow	Per animal per kg per day	7.1	7.4	7.2	6.8
Share of buffalo milk	%	69%	71%	42%	51%
Ag. yield for buffalo	Per animal per kg per day	4.5	4.7	4.4	4.9
CAGR of milk production (2010-11 to 2014-15)	%	3.7%	4.6%	3.3%	3.7%
Per capita milk availability	Grams per day	318	413	219	307
Total milk processing capacity	Million litres per day	25.0	7.8	26.6	120.6
Share of private sector capacity	%	90%	59%	73%	61%

Most of the milk (around 70%) in India is going through so called 'unorganized channels' by local vendors or direct sales from producers to consumers, 30% is going through 'organized chains'. Milk processors in the organized value chain range from local cooperatives, private processors that are active in specific states or nationwide to multinational companies like Danone and Nestle. Each with its own collecting system, value chains and associated farmers. Loyalty of the farmers to a specific processor is generally low. Milk production per cow is on average 1.35 tons/cow/year, compared to an average production in the Netherlands of 8 tons/cow/year (FAOSTAT).



About 80% of the milk in India is being produced by family farmers, most of them have 2-8 cows. In these farming systems, milk cows have an important function for providing a continuous cash flow for the farms, that also produce vegetables and/or contract farming of, for example, sugar cane. The milk price and recurring droughts are major points for concern to the Indian family farmers. Other challenges the farmers are confronted with is the growing demands on food safety and reduction of antibiotics.

Recently, the Indian Government released a new law on animal welfare, titled the 'Prevention of Cruelty to Animals (Regulation of Livestock Markets) Rules, 2017. This law is to ensure welfare of the animals in the cattle market and ensure adequate facilities for housing, feeding, feed storage area, water supply, water troughs, ramps, enclosures for sick animals, veterinary care, proper drainage, etc.

In this dynamic environment family farmers have to decide on new strategies for their farms and on investments in innovative methods and technologies. This offers a new market to Dutch companies active in dairy technology and knowledge, if they are ready to adapt their products and services to the specific Indian demands and circumstances.

1.3 Concept of frugal innovation

The Indian 'family farmer' market for Dutch companies is enormous, if they succeed in transforming their 'high tech' products and services into frugal, 'mid-tech' products and services. Dutch companies have demonstrated knowledge and a wide array of products and services to improve animal housing systems and milk quality, which are also interesting for India. But the Dutch technology is of high quality and expensive, aiming at the 'top of the pyramid'. A successful entry into the Indian market of Indian family farmers requires affordable and robust ('frugal') systems and products that are suitable for the Indian climate and market conditions.

The concept of 'frugal innovation' finds its origin in the Indian approach of "Jugaad", which is a Hindi word for an innovative fix or a simple work-around, a solution that bends the rules, or a resource that can be used in such a way. Related to innovations it is also often used to indicate creativity; to make existing things work, or to create new things with meagre resources (Wikipedia)¹. In 2013, the Centre for Frugal Innovations for Africa was started in the Netherlands, as a strategic collaboration between Leiden University, Delft University of Technology and the Erasmus University Rotterdam. The goal of the centre is *"to identify the conditions under which frugal innovations are more likely to improve the lives of consumers and producers at the Middle and Bottom of the Pyramid"*.

In the Family Dairy Tech project, frugal innovation was translated to suit the challenge for Dutch and Indian companies, farmers and knowledge institutes: *"How can Dutch companies for dairy cattle housing systems adapt their products so that they can enter the Indian market and contribute to sustainable and profitable local dairy farming in Baramati-Pune?"*

Commercialization of technological innovations also requires new business models for Indian farmers, collaboration and new value chains in India and collaboration between

¹ In 2012, a comprehensive book was published by Wiley, in which Radjou, Prabhu and Ahuja describe and elaborate the concept: *"Jugaad Innovation: Think Frugal, Be Flexible, Generate Breakthrough Growth"*. (Wiley. p. 288. ISBN 978-1-1182-4974-1).



Dutch and Indian companies. Technological and commercial innovations therefore go hand in hand. The Indian partner in the project, the innovation centre Krishi Vigyan Kendra (KVK) Baramati, has developed free range stable based on an Israeli system. In this so-called Loose-Housing System KVK experiments with breeds, feeding systems, water supply and various cow separation systems.

Frugal innovation is a difficult task for Western firms, because their business models and whole organizations are designed for the development of advanced products for the "top of the pyramid". Experiences from other sectors suggest that frugal innovations are mostly developed by local R&D subsidiaries of Western firms in the emerging countries itself, with a substantial degree of autonomy, including product-portfolio responsibilities (Zeschky, Widenmayer & Gassmann, 2011).

J.C. Diehl, Assistant Professor at the Faculty of Industrial Design Engineering of Delft University of Technology, mentions as preconditions for successful frugal innovations: "a multidisciplinary team, participatory research, co-creation with users and an approach of modelling as well trial and error". All, aspects that fit very well with the research approach of the universities of applied sciences and the framework of the Indo-Dutch consortium for the Family Dairy Tech project.



2 Dairy farming in Baramati

2.1 Dairy farming in Maharashtra

Maharashtra is the 7th largest milk producing state in India. During 2014-2015, it produced 9.4 million MT. The Major milk producing districts are Pune, Ahmednagar, and Kolhapur which hold the share of 36% of total milk production in the state. Only 20% of milk production is processed and moves through the organized sector. Of the 24000 million litre of milk being processed 30% is processed by cooperative processors and 70 % by private processors. Of the milk produced in the state, 14% was produced by indigenous cows, 41% by cross breeds and 42% by buffaloes (FASAR & YESBANK, 2016).

The total registered milk processing capacity in Maharashtra is 26.6 million litres per day with 58% of that under private sector. Some of the major private players operating in the state are Parag Dairy, Schreiber Dynamix and Prabhat Dairy.

The Dairy farming sector in Maharashtra is traditionally based on small and marginal farmers. In 2010, the state counted 136.000.000 farmers' families. A number that shrunk 100.000 since 2005. Of the total labour force of Maharashtra 52.7% work in the agricultural sector. In absolute numbers of people working in the dairy sector Maharashtra ranks fifth out of seventeen Indian States. Family dairy farmers produce about 79% of the milk and own land holdings ranging from 0.45 – 1.5 hectares. The average small farmers own one or two milking cows to generate cash flow for their mixed farms. Farmers that sell to processors bring milk to collection centres owned by the processors and managed by village-cooperatives or independent service providers. In these "Village Level Milk Collection (VLCCs)" the milk is collected in cans after testing. Farmers are paid on the basis of fat and SNF content in the milk. To boost milk procurement many cooperative dairies and the private company have set up larger collection centres in the rural areas, known as Bulk Milk Collection Centres.

Most of the people employed in the Dairy sector are working in the primary production. Dairy farmers, the producers of milk, represent 60% of the of the employees in the dairy sector in Maharashtra. Processors of milk employ 30% of the labour in the dairy sector in Maharashtra. The remaining 10% is represented by advisors, mostly para-veterinarians (80%) and veterinarians (20%). It has been mentioned that 70% of the para-veterinarians are not educated. Veterinarians are mainly focusing on animal health, rather than breeding and nutritional aspects in dairy farms.

During the last decennium the sector is going through a process of up-scaling and many farmers and (private)investors decided to specialize or invest in dairy. Companies are diversifying into high margin value added products like cheese, UHT milk, ice cream, whey based products, etc. Still, the majority of demand of traditional Indian dairy products like curd, paneer and buttermilk is catered by the unorganized sector. In the growing group of urban consumers there is a gradual shift towards packaged dairy products and there will be demand for new economically viable technologies for the manufacturing of these products. Companies are looking out for innovative packaging solutions which are economically viable for value added dairy products like cheese, long shelf life milk, ice cream, flavoured milk etc. to ensure better quality and improved shelf life.

Drought vulnerability of the Dairy sector is a major challenge in Maharashtra. The widespread drought in Maharashtra due to the insufficient rainfall, especially in the leading



milk producing districts of Ahmednagar, Solapur and northern Nashik, has resulted in a fall in the state milk production. For example Indapur-based Sonai Dairy, District Pune reported a drop of around 60% in milk procurement: *“Last year (2014) they used to procure around 22 lakh litres per day and now it has dropped to 9.5 lakh litres per day.”* The State of Maharashtra rations the water supply to manage the shortage of water, the Pune Municipal Corporation has approved an alternate day water supply plan since September 1, 2015, with levels of water in dams supplying water to the city falling to critically low concentrations.

The development of the dairy sector is supported by various actors on different levels. The National Dairy Development Board’s scientifically planned National Dairy Plan Phase I (NDP I) focuses on strengthening of dairy cooperatives in Madhya Pradesh and Maharashtra. The focused approach would emphasise on Ration Balancing Programme (RBP), fodder demonstration, Village Based Milk Procurement System (VBMP), pedigree selection, strengthening semen station and conserve & develop indigenous breeds.

On the state level the Dairy Development Department functions as a separate department. The head of this department is referred to as the “Milk Commissioner”. To strengthen chains from village Co-op Society to Talula and District Sangh to Govt. dairy, a post of District Dairy Development Officer was created at District Level in the year 1978. To help him, the posts of Assistant District Dairy Development Officer, Assistant Registrar (Co-op Society) and other posts were created.

The Indian Council of Agricultural Research established Krishi Vigyan Kendras (KVKs). The KVKs have the mandate to assess new technologies, to train farmers in these new technologies and to demonstrate and disseminate new technologies in agricultural production. KVK Baramati has been distinguished as the best KVK of India.

The farmers are also supported by cooperative and private processors, who organize milk production awareness camps and offer training and advice on fodder diets for cattle, caring for livestock, disease prevention, breeding and boosting milk production. Some processors mediate in loans for farmers or pay milk producers extra bonuses per litres. This is also part of the strategy of tying farmers to their company, as the loyalty of farmers to a specific processor is generally low.

2.2 The Dairy sector in Baramati, Pune District

Description of production environment and developments

Pune district forms together with the districts of Satara, Sangli, Solapur and Kolhapur the ‘Western region’ of Maharashtra. In 2007, this region produced 38.3% of the total milk production of Maharashtra (2.3% coming from local breeds, 18.5% from cross breeds and 17.5% from buffalo) (National Dairy Research Institute, 2012). Baramati is a city and a Municipal Council in Pune district in Maharashtra, India. The city of Baramati counts around 60.000 inhabitants and situated about 80 kilometres from the city of Pune (6 million inhabitants). Baramati and the surrounding areas are mostly depended on agriculture as the main source of the income. The land in the region is very well irrigated because of the canals from the Veer dam in the Nira river in Satara south of Baramati and the Karha river north of the city. These rivers provide irrigation to the farmers. Main crops of the farmers include sugarcane, grapes, sorghum, cotton and wheat. Besides agriculture, most farmers have some cows as a cash source of Income. The Family Dairy Tech project focusses on the working area of KVK- Baramati, which is the southern half of Pune district (see figure 1).

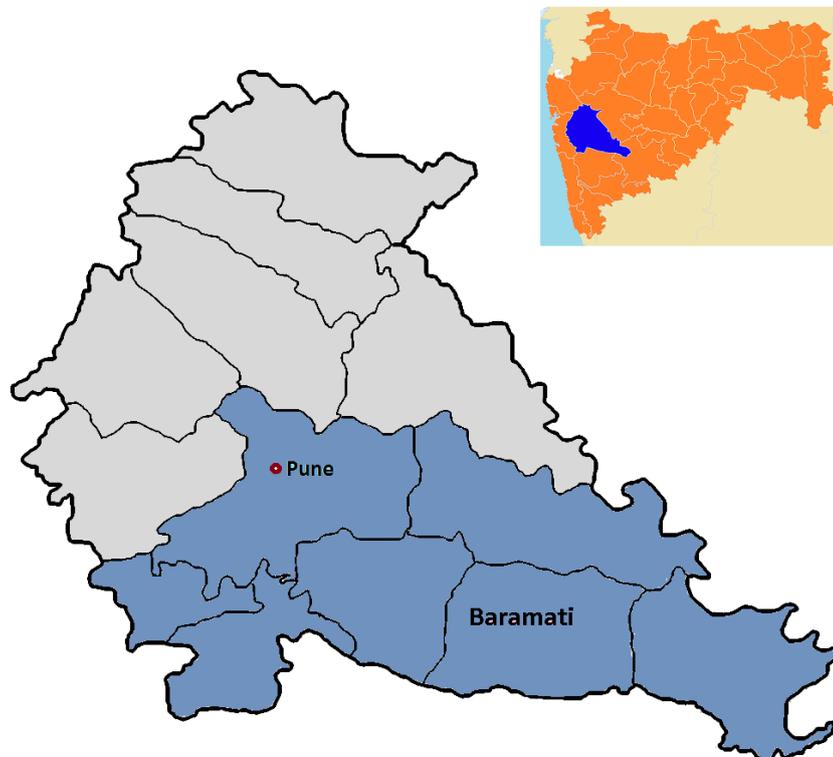


Figure 1: Working area of KVK-Baramati (Wikimedia commons, 2016).

The dairy sector in Baramati is a very dynamic and crowded sector. It consists of 12,000-15,000 dairy farmers that specialise their farms in milk production. The majority of these farmers sell their milk to cooperative processors (45%) and private processors (45%). Only 5-10 % of the dairy farmers is selling their own milk at the doorstep or at local markets. There are four major dairies in Baramati: Schreiber-Dynamix, Nandan, Heritage Foods and Yash Agro. Baramati region has a total production of around 3 lakhs (300.000) litres of milk per day. All processors have their own collection network of village collection points, bulk milk coolers and milk chilling centres. More and new players are still entering the market.

About 7000 Farmers are connected to Schreiber-Dynamix Dairy with the production of 90,000 litres of milk per day. Schreiber-Dynamix is a modern company, that does not market liquid milk. Its primary business is manufacturing and exporting products like cheese, butter, ghee, casein, lactose and UHT milk. The company has its own brands but also supplies dairy products to other companies like Danone and Nestlé. Schreiber-Dynamix took the initiative to raise awareness among their suppliers on the importance of antibiotics-free milk.

Nandan Co-operative Dairy procures 1.5 lakhs (150.000) litres of milk every day from the surrounding region of Baramati. Nandan dairy has two business lines: business-to-consumer with traditional products like pasteurized milk, ghee, lassi, etc. and business-to-business supplying milk to Schreiber-Dynamix Dairy on a yearly contract basis.

Yash Agro is a private milk processing company with a production capacity of 15.000-20.000 litres of milk per day. Recently, Yash Agro entered a joint venture with the agricultural



company Baramati Agro to upgrade to a hygienic milk chain ('untouched milk') and expand their dairy products.

The consumer market for Baramati dairy producers can be divided into rural and urban consumers that have different behaviour and demands. The average daily consumption of dairy products in Baramati is around 260 gr per person per day. There is a major increase in milk consumption.

Urban inhabitants are changing their food consumption patterns. Most of the urban consumers prefer processed products. Currently, most of urban consumers consume mainly fluid milk followed by ghee, butter, curd and other dairy products. These products are consumed year round, irrespective of seasons or occasions. Products like ice cream, flavoured milk, lassi, and buttermilk are consumed only during summers.

Rural consumers are spending more on dairy products, mostly fluid milk. According to rural consumers, the high-quality milk is fresh milk with high-fat content which is clean and white. They consume traditional products like ghee, buttermilk, butter and curd. Buffalo milk is preferred over cow milk because of higher fat percentages (6% and 1,5-3,5% respectively) and therefore better taste, but buffalo milk is also more expensive. Therefore, the majority of the milk sold originates from dairy cows.

The overall dairy consumption is growing and expected to continue growing in coming years. It is expected that milk with lower fat percentages will become more popular in future. There is a specific niche market for indigenous cow milk, as it is the consumers' perception that milk from an indigenous cow (i.e. 'A2 milk') is healthier than the cross breeds (i.e. A1 milk') and the leading opinion is that milk from indigenous cows has medicinal value.

2.3 Dairy value chains

A dairy value chain is characterised by a sequence of related business activities (functions) from input supply to final sale; "from grass to glass". A set of enterprises (operators) are performing these functions of producers, processors, traders, and distributors in the milk column. The enterprises are linked by serious business transactions (GTZ, 2007). Figure 2 shows the current dairy value chain in Baramati as drawn by Marri & Tingiira (2017) based on FASAR & YESBANK (2016) and Fleuren (2016). This is an example of a 'formal' dairy chain.

According to Saha et al. (2004), the Indian dairy sector can be distinguished in formal and informal channels or chains. The formal chain fulfils the functions of milk producing, collecting, processing and distributing before the milk is purchased by individual consumers. The informal chain is characterised by short chains of milk producers, collectors/distributors or very large chains of a producer and various traders. They report that in India 92% of the milk is channelled through the informal chain.

Fleuren (2016) however reports in her Baramati dairy sector inventory study that in Baramati 90% of the milk is channelled through the formal chain. In the formal dairy chain she mentions a cooperative milk processor (Nandan) and private processors (Govind and Schreiber Dynamix). These are examples of mainstream dairy milk chains. Milk quality and food safety checks are normally only done in formal milk chains at milk collection and/or processing level. Fleuren (2016) reports milk quality differences between the cooperative and private milk processors concerning antibiotics acceptance. Schreiber Dynamix for example has a separate processing line without antibiotics for high quality customers segments, such as Danone and Nestlé.

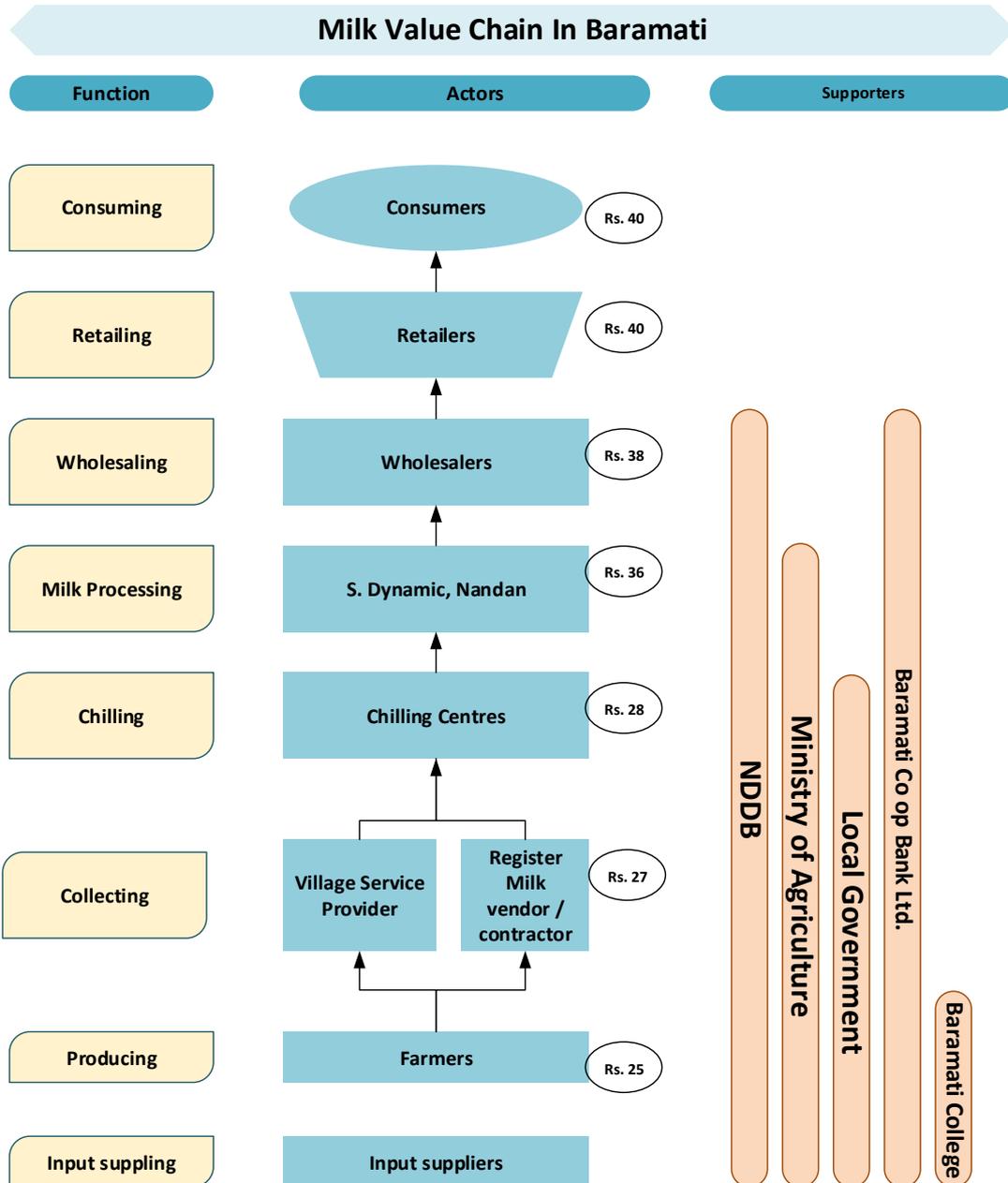


Figure 2: Existing Dairy Value chain in Baramati. Marri & Tingiira (2017), based on YESBANK (2016) and Fleuren (2016).

Ingale (2017) designed the chain map of the private processor Yash Agro in Baramati, as shown in figure 3, based on a workshop during the FDT seminar in April, 2017. Yash Agro has a joint venture with Baramati Agro.

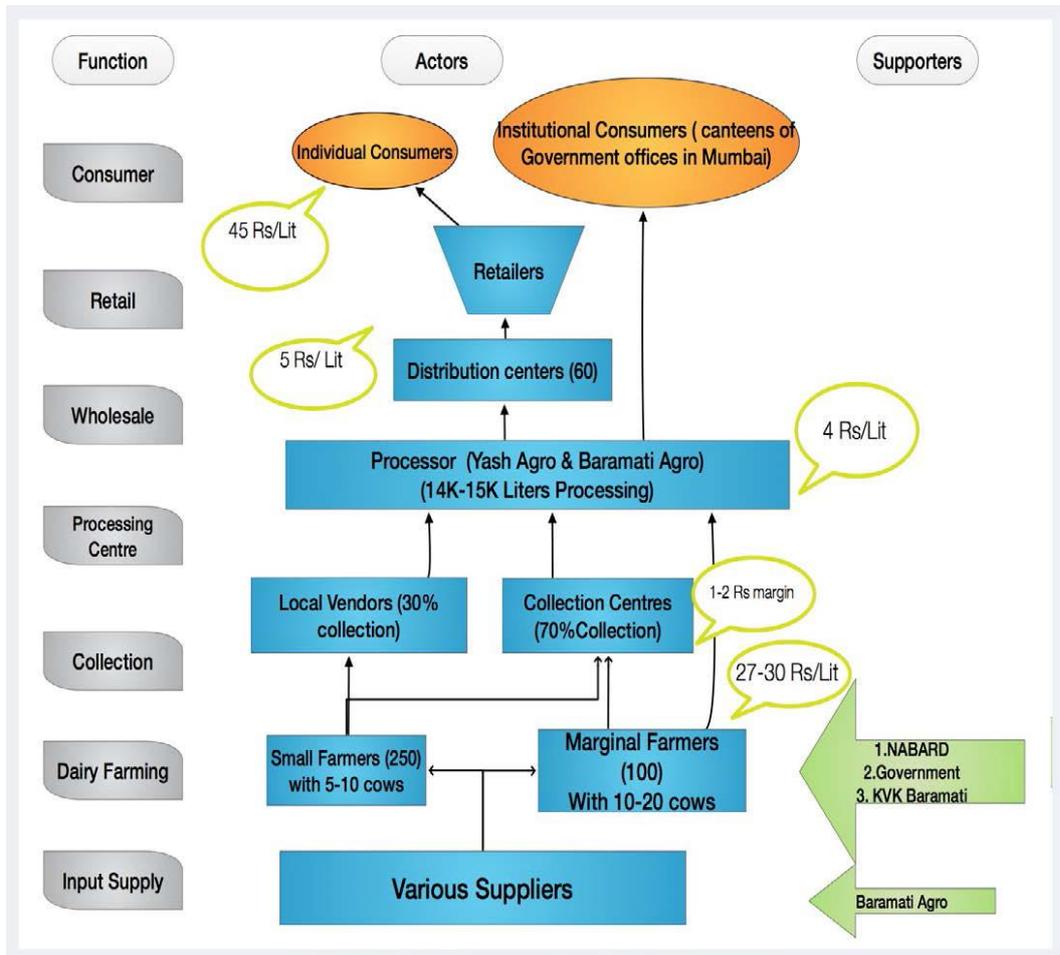


Figure 3: Yash Agro dairy value chain. Source: FDT workshop 4 April, 2017 (Ingale, 2017).

An important function in the dairy chain is the role of the milk collection. Most milk collections centres (MCCs) have a bulk milk cooler (BMC) so the milk can be chilled to 4 °C before being transported to the processing plant. Farmers on average live around 10 km’s from the MCCs (Fleuren, 2016). The local vendors are delivering the unchilled milk to the processing plant, so the risk of milk quality reduction is high.

Patil (2017) describes 2 short dairy value chains of A1 and A2 milk respectively as examples of niche dairy chains (figure 4 and 5). Milk producers or dairy farmers are directly delivering to consumers after packaging the milk in plastic bags. In both cases, the milk is not pasteurized nor homogenized. Their health-conscious customers are paying an extra price for the freshness and the full fatness of the milk. The A2 milk consumers also consider the health claims of the A2 milk, such as risk reduction of allergy, diabetes type 1 and heart diseases (Fisher, 2014; Bongiorno, 2014).

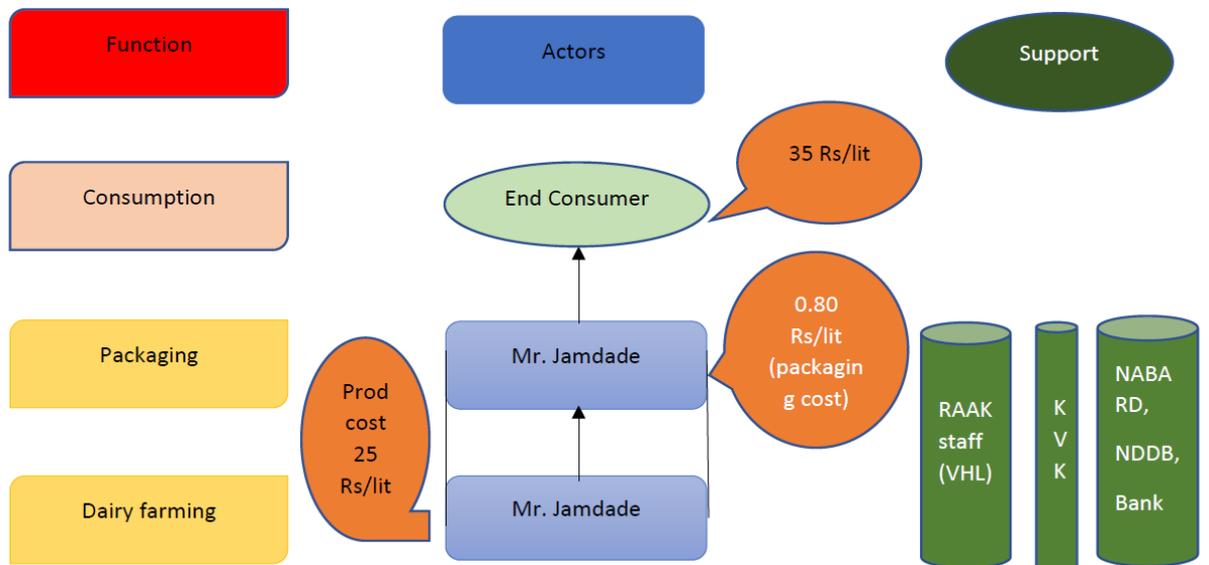


Figure 4: Short A1 milk chain.

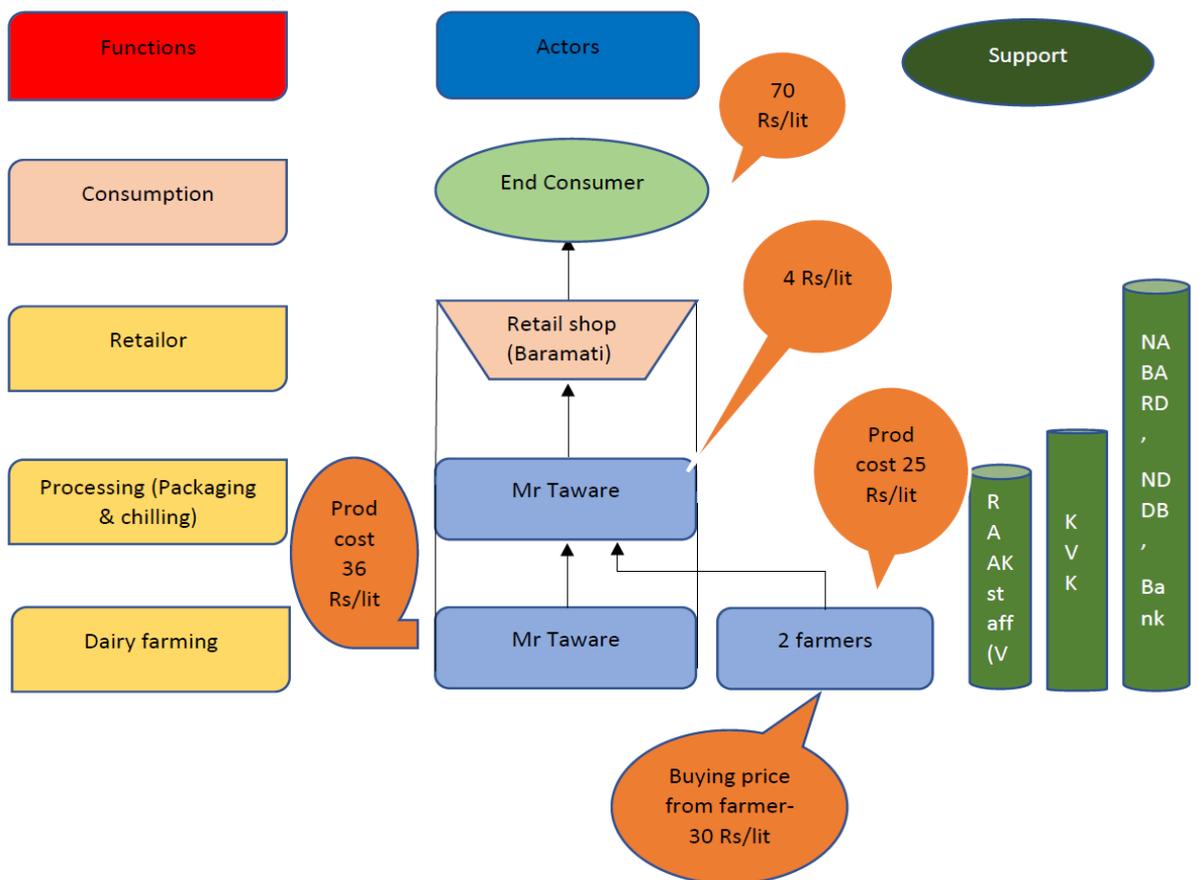


Figure 5: Short A2 milk chain.

2.4 Dairy farms

Initially in the project a group of 8 farmers in or near Baramati were selected by the KVK as a potential customer group for implementation of new technologies and improved farming practices. In the following pages a general overview of those selected farms is given (see table 2). First presented are their farming resources and next their farming practices. Finally the overall farming system of this group is discussed including their management issues. This inventory is made based on an in depth observation and interviews of those farmers in the initial stage of the project, November 2015.

Farming resources

The animals ensure the key income for the farmer through milk, and for some farmers also through manure and sales of animals for breeding or milking purposes or as a draught animal. On average they have 41 dairy animals, including young stock.

Table 2:

Farm data of the eight local dairy farms, based on interviews RAAK farmers 2015.

Indicator	Average	Lowest	Highest
Number of cows	21	10	40
Number of heifers	13	6	33
Number of calves	7	3	16
Breed (% HF)	66	0	97
Milk yield / cow / lactation (ltr)	3581	2500	4750
Estimated annual milk production	60,000	20,000	170,000

All farmers have milking machines (picture 2) and chaff cutters (picture 1). In half of the cases, there is also a tractor owned by the farmers. A turn plough is used in most cases, however most land management related activities are performed manually.



Picture 1: chaff cutter.



Picture2: milking machine.

The land is used both for growing animal feed and arable crops. The land used for feed crop production is between 1-3 ha, another 2-4 hectare is used for all types of other crops. All land is usually owned by the farmer.

Generally there is 1 farm manager/owner, 2 labourers for crop management (harvesting, seeding, fertilizing, etc.) and 2 for cow management (feeding, milking, cleaning



the barn, etc.). The farm manager has a college or university degree or is educated up to 11-12th standard (high school until 18 years old). The other labourers are usually educated up to 6-8th standard (high school until 14-15 years old). Both men and women are working in the farm. In some farms the women only take care of the administrative tasks and the household, whereas in other farms managing and executing operational activities for crops and cows can be a women's task.

The farms within this project make use of a shed and a 'loose house'. The loose house is considered as the area in which the animals are kept during the day and the night, where they have space to walk around. The size of a loose house is about 30m x 30m. The flooring is just sand or a mixture of sand with sugarcane trash (the dry parts of sugarcane). There is usually limited shade available in the loose house.

The shed is the area in which the cows are milked and fed roughage as well as concentrates. There is usually a (roughened) concrete flooring in the shed. Cows are tied in the shed for milking and feeding. Usually the shed and loose house are separated (picture 3), but there is one case in which these two places are connected (picture 4).



Picture 3: Separated loose house and shed.



Picture 4: Connected loose house and shed.

Calves are separated from their dam soon after birth. They are kept in a shed in a tight housing system from the moment of birth onwards (picture 5). Calves are kept there up to six or seven months of age. After that they are kept in a loose house together with the cows.



Picture 5: female calves in a tight housing system.

Key farming practices

Calves do get milk from their own dam until three days after separation. From three days onwards calves are fed with whole milk, usually twice a day. Usually the calves are weaned at about three months of age. The calves are fed twice a day with roughage and calf starters. Watering is done at least twice daily, usually by the farmers' wife.

There are 2-4 milking machines (bucket with cluster) available, which are connected to a pipe and vacuum pipeline system in the roof of the shed (picture 6). There are quite some differences between farms concerning milking management, especially with the routines around milking. One farmer is disinfecting the teats before milking, massaging the teat to stimulate milk let down, disinfecting the teats after milking and disinfecting the cluster before it is connected to another cow, but the majority of the farmers is performing only a part of these tasks.

Milking one cow takes around seven minutes. Milking is averagely completed within one to two hours. Milk production is not recorded by the farmers. The milk production is measured at the milk collection centre, as well as the fat percentage and the SNF (Solid Not Fat) percentage of the milk. These are the only quality parameters known by the farmers.

The quality standards applied are 3,5% fat and 8.5% SNF and milk should not contain dust, dung or foreign objects. Milking is approximately done between 4 o'clock and 5:30, the interval between milking is mostly 12 hours.



Picture 6: milking.



Farmers on average decide to inseminate the cows in their second heat, which means that the first insemination is performed around 60 days after calving. This insemination is done by the para-veterinarian (picture 7). This para-veterinarian can be linked to a private, governmental or cooperative organisation. In some cases the farmer decides with which bull the cows have to be inseminated, in some cases this is decided by the para veterinarian. The only choice that a farmer has in deciding for a bull is to choose for the percentage of Holstein Frisian in the bloodline of the bull. Breeding characteristics of the bull are usually unknown by the local dairy farmers. Breeding characteristics or any other breeding values of the dams is lacking as well, as usually only the dates of insemination of heifers/cows is recorded by the farmers in their agenda's. In some farms even this data is not recorded. The average insemination age of the heifers in this project is 14-16 months. Except from one farm that is having indigenous dairy breeds, cows are inseminated artificially.



Picture 7: para-veterinarian preparing straws for insemination.

Cows are fed twice daily in the shed usually while milking in morning and afternoon. In some cases farmers installed feed bunks in the loose house, which ensures that there is also roughage available for the cows during the day. The most common roughages fed in the winter season are: maize (picture 8), sugarcane (whole sugarcane or sugarcane tops)(picture 9), sorghum (green sorghum) (picture 10) and hybrid Napier grass(picture 11). In some cases cows are also fed alfalfa, soybeans, and/or marvel grass. The area in which these local dairy farmers are active is considered as a very 'green' area, which means that there is relatively much water available. Cultivation of crops like sugarcane and hybrid Napier grass is very popular in this area.



Picture 8: Maize.



Picture 9: Sugarcane.



Picture 10: Sorghum.



Picture 11: Hybrid Napier grass.

Table 3 indicates the crop yields, the growth period and the harvesting moments of the most commonly cultivated crops in Pune district.

Table3:
An overview of yields, growth period and harvesting moments of most common crops for feeding cows.

Crop	Yield	Growth period	Harvesting moment
Hybrid Napier grass	100.000 kg	Perennial crop	Every 55 days
Maize	60.000 kg	Seasonal crop (3 seasons)	Once per season (65-75 days)
Sugarcane	50.000-60.000 kg	Perennial crop	Every 8 months
Sorghum	30.000 kg	Seasonal crop (3 seasons)	Once per season (65-75 days)
Alfalfa	30.000 kg	Perennial crop	Every month

All farmers are also providing pelleted concentrates to the cows (picture 12). In some cases these pellets are processed and provided by the milk processors, but also feed companies that provide pellets and concentrate like products are active in Pune district. Wheat bran, cotton seed cake (picture 13) and groundnut cake is also fed to the cows in some farms. Most of the farmers are adding minerals to the feed in order to maintain or optimize the general herd health.



Picture 12: preparation of concentrates.



Picture13: cotton seedcake.



Manure is manually collected in the farm. The manure is scraped together, collected in a bucket and then transported to the manure pit for storage. The manure is used to fertilize the agricultural land. If the manure becomes too dry to add it to the agricultural land, water is added to make slurry. In some cases manure is immediately applied on the agricultural land.

Veterinary care

If clinical observations do not provide enough information about the nature of a disease, a veterinarian will be called for further examination. Surgeries like abomasum displacements are performed by a veterinarian. A veterinarian can be private, from cooperative companies/organizations or from the government.

Foot and mouth disease (FMD) is a very common disease in India. The Indian government provides vaccinations for all cloven-hoofed animals to prevent outbreaks of FMD. All farmers in this project vaccinate against FMD. Some farmers also vaccinate their herds for haemolytic septicism (HS), tick fever and/or brucellosis. Antibiotics are used as curative therapy. In some cases farmers decide to use herbs as curative treatment, mainly in case of a retained placenta. Homeopathy is only used in one farm, in order to increase the milk production.

In most of the cases, the para-veterinarian or veterinarian treats the animals. However, most of the farmers have quite an extensive collection of medicinal drugs available on their farm. Minor health problems are treated by the farmers themselves.

Hoof health does not seem to be a problem on the farms within this project. The farmers indicated that the incidence of hoof problems was quickly reduced after introducing the cows to the loose housing system. All farmers indicated that hoof trimming was done once a year by so called community people. These community people are specialised and have the required equipment for basic hoof trimming.

Farming System and Management Issues

Farmers were questioned about the cost price for one litre of milk and the price they get payed for one litre of milk. Farmers seem to have quite a good view on the costs, although it is expected only operational costs are included in the cost price. Table 4 shows the cost prices and milk prices of the local dairy farmers within this project.

Indicator	Average (rupees)	Lowest (rupees)	Highest (rupees)
Cost price	17,50	14	25
Milk price	22,70	18,50	35

In some of the local dairy farms milk production is the main source of income, whereas in other farms the main source of income is from agricultural land. In some cases the income is derived for 50% from agricultural land and 50% from milk production.

Processors are offering support services to the dairy farmers in order to keep them 'on board'. Due to the fact that there are no written contracts, farmers have quite some



opportunities to deliver milk to another processing station if they are not satisfied with the services of the processing plant. A few examples of support services are reduced costs for inseminations and other activities performed by a para-veterinarian, finance for investments, supply of concentrate and concentrate like products for reduced costs and providence of subsidies for milk equipment and chaff cutters.

In most cases the milk collector is the one that is initially contacted for advise considering milk quality and production levels. There is frequent contact (twice daily) between the milk collector and the dairy farmer. The fact that there is a high trust level between those parties makes it convenient to request advice.

Since halfway 2015, there is a ban on slaughtering cows in Maharashtra. The ban already existed in other provinces, but now also Maharashtra followed. This has major consequences for the farmers, because this will result in an excess of non-lactating animals in the herd. Bull calves and old cows are causing the majority of problems, because they are not productive. Especially the old non lactating cows are affecting the farmers finances. In the past they were slaughtered or used as draft animals. An option is to re-sell the cows to farmers, indicated by the farmers in this project as 'poor man'. One farmer indicated that bull calves are sold for 100-200 rupees per calf, old cows are sold for 25.000 rupees per cow. One farmer is offering his old cows to citizens with health problems, families with low incomes and pregnant women and to families with children with health problems.

Farmers were asked about the issues they have to deal with in their farm management. The major aspect that was indicated was to get enough labour. People in India are not really willing to work on a farm anymore. It is considered as a physically heavy job and therefore working in cities seems to be more attractive to them. Farmers do not have contracts with their labourers. They usually arrange a living and some food for the labourer and additionally some salary. Labourers usually come from other provinces in India, which means that for instance if there are traditional parties (like marriages or Diwali), the labourer goes home.

When farmers were questioned about the priorities they have to deal with day by day, they all indicated 'feeding'. The farmers are very well aware about the importance of feeding the right rations with nutritional values to their cows, but are experiencing difficulties with this.

Farmers were also questioned about their farming goal. They have one thing in common: to grow. To grow can be interpreted in two different ways: to grow in the number of animals or to grow in farm production level. However, most of the farmers are aiming to grow in number of animals. Either by doubling the size once, twice or three times. Some farmers indicate to aim for a short term growth (one year), some others for a longer term (five to ten years).

The target group of this project is a group of farmers with a straightforward way of thinking. The fact that all the farmers in the target group are belonging to the 30% that keep animals in loose housing systems, confirms that statement. Farmers are very willing to adapt or change farm management, but they have to see before they believe.

It has to be stated that more or less all the required technologies are available in India. The high price restrains the local dairy farmers to buy these technologies. The average investment possibilities by getting a bank loan are 100.000-200.000 rupees per farm.



3 Innovating the Baramati dairy sector

3.1 Innovations in barn design

The overall purpose of the working group “Better Housing System” is to increase the quality of milk production per cow by providing a good barn, which in turn leads to increased profitability of the farmers in the Pune district in Maharashtra, India. It further aims to optimize cow comfort and prevent heat stress by providing an adequate barn design and climate control system. The two key indicators are:

- a) increased quality milk production per cow as a result of a higher cow comfort and
- b) lower heat stress and better stable management.

Frugal innovation is at the heart of all developmental activities. Frugal criteria are defined as simplicity, affordability, sustainability, satisfactory quality and longevity of cows.

The following key activities related to the work package “Better Housing System” were undertaken with local farmers in the Pune district, dairy experts in India and the Netherlands as well as representatives of Dutch companies.

- **October 2015:** Family Dairy Tech Kick-off Workshop at Weidevol BV, Zwartsluis, the Netherlands. The work package “Better housing” was formed.
- **November 2015:** Intake interviews and field work for creating a list of requirements by Ms. Milou Fleuren, Vetvice, the Netherlands. Heat stress and poor stable management were determined as the key issues.
- **March 2016:** One week long fact-finding mission to Baramati, Pune district, India. Reconfirms the purpose and the goal as stated above.
- **June 2016:** New barn design 1.0 and evaluation by Naresh Kondala and Akshay Shelke.
- **December 2016:** Workshop at Dutch dairy campus, Leeuwarden where three posters from Saxion have been presented and discussed with Indian and Dutch experts in barn roofing materials, cow cooling and modular barn design.
- **February 2017:** Actual data collection in terms of barn temperature and milk production for nine selected cows in three different barns at Baramati.
- **April 2017:** Workshop at Agriculture Development Trust (ADT), Baramati, was conducted to educate farmers about existing developments related to heat reduction technologies for the barns.
- **April 2017-June 2017:** Implementation of frugal innovations at existing barns in Baramati and performance evaluation in terms of reduction in barn temperature and its effect on milk production.
- Several one-on-one meetings were planned with industry experts and Indian and Dutch dairy experts. More than ten students worked on this part of the research project from VHL and Saxion. At least three researchers from Saxion with diverse research backgrounds have participated.



Based on the activities and proposed barn designs mentioned above, we have delivered the following output:

- Various practical solutions to reduce heat stress in the barn;
- Advice on how to reduce heat stress for three participating farmers at Baramati;
- Design 2.0: New standard barn design taking into account a list of requirements of local farmers;
- Design 3.0: Next generation barn design with state of the art design and infrastructure;
- Three posters about cow cooling, roofing, and overall barn design;
- An educational poster that captures all the elements in English as well as in Marathi (local language in the Pune district).

Why are changes needed?

Two key issues identified limiting good production of quality milk and giving good welfare to the cows are a poor barn design and hostile climatic conditions. The Indian mid-size (up to 500 litre milk production per day per farm with average 10 litre per cow per day) dairy farmers in the Pune district are not qualified enough to design a dairy barn themselves. Most of the participating farmers within this project have built their own barns without any expert advice in terms of structural design and choice of materials. Moreover, these barns were built without considering the local climatic situation (up to 45°C in summer time), local breeds and possibilities of future expansion. As an example, many participating farms have HF (Holstein Friesian) cross breed cows, that are certainly not suitable for hot climatic conditions. This situation needs urgent attention and therefore the focus within the “Better Housing System” work package was targeted to the following elements:

1. How to reduce the heat stress in the barn?
2. Which solutions can bring temperature down in existing barns?
3. Design of a new but traditional barn (Design 1.0 and 2.0), taking into account the issue of heat stress and cow comfort.
4. Design of a next generation barn (Design 3.0), taking into account the integral solution to prevent heat stress and provide optimal cow comfort.

It is a well-known fact that an increased temperature in the barn has a negative effect on the milk production. An average barn temperature between 16 and 25°C is suitable for the daily metabolic activities of the cow and to maintain the cows’ body temperature at 38-39°C. However, above 27°C a cow goes into a mild heat stress, between 33-37°C into a medium stress state, and above 37°C into a severe heat stress. There is a clear relationship between the cow standing in the barn and the milk production (Berg, 2016). The cow standing is connected to the heat stress and the comfortability of the bed. Ideally a cow should lie down for 12-14 hours per day. According to the Dutch dairy company GEA, each hour a cow is standing instead of lying could cost one litre reduction in milk production. Therefore, it was decided to monitor the relation between (barn) temperature and milk production of nine selected cows from three participating farms. Three cows each from KVK farm Baramati, Mr. Jagtaps’ farm in the village Pandare, Baramati and Mr. Barges’ farm in Baramati. It is important to mention that the KVK farm was built as a model farm. Mr. Jagtaps’ farm is a large farm with a milk production of about 500 litres per day. Mr. Barges’ farm is a



smaller farm with milk production with about 200 litres per day. These three farms were representative for the farms in the region.

Most of these nine cows were in lactation phase 1 or 2 to ensure steady milk production (see table 5 for specific information). All of these cows were in a healthy state at the start of the research. No changes were made in terms of daily diet (feed) and water intake throughout the study to rule out any additional effect of these parameters. The benchmarking of each farm included the barn structure, height of the barn, roofing type (closed or open structure), roofing material, infrastructure, number of cows and other relevant information. The main measurements taken include morning and evening milk production, inside and outside barn temperature, inside and outside roof temperature. These readings were recorded from the first week of February till the first week of April 2017 (an 8-week period) when the local temperature started to increase in the Pune district (shift from spring to summer season). All the results were discussed in detail. **Error! Reference source not found.**5 shows some of the data gathered. Out of nine participating cows, six cows (with all phases of lactations) show a clear decrease in milk production during the 8-week period. During field observations, it was noticed that the average roof temperature already rises in the beginning of April to 47°C and that the cows were showing clear signs of heat stress. Because of the narrow roofing structures, many cows were exposed to direct sun light. The overall heat stress of the cows can be a result of tin based metal roofing, low roof height, closed and narrow roof structure and poor ventilation. There might be more factors, but the results clearly show the negative effect of temperature on milk production.

Table 5:

Relation between inside barn temperature and milk productivity data for selected cows in the three barns under study at Baramati, District Pune.

Cow number	Lactation number (Feb 2017)	Milk production per day (4 th of Feb till 12 th of April)	Average roof temperature (Feb-April 2017)
KVK-14	2	13.0 – 8.5 l	↓ 4.5 l/day
KVK-101	2	20.5 – 13 l	↓ 7.5 l/day
Jagtap (GY-54)	1	21.5 – 16 l	↓ 5.5 l/day
Barge (HO 119988)	3	22.0 – 13.5 l	↓ 8.5 l/day
Barge (HO 119991)	2	15.6 – 0 l	↓ 15.6 l/day

Innovations in barn construction and utilities

It is now indicative that the inside barn temperature plays a vital role in contributing to heat stress, which results in lower milk productions. The key factors that are identified for heat stress are:

- the average temperature that is high during the summer (March-July);
- tin based metal roofing which is a good heat conductor;
- closed roofing structure that doesn't allow trapped heat (hot air) to escape;
- low height of barn (2.5 - 3.5 m) causing severe effect of roof radiation on cows;



- e) poor ventilation as a result of the factors mentioned in c and d;
- f) direct sunlight when cows are standing in the barn;
- g) high cow density;
- h) poor access to drinking water and
- i) overall poor barn design.

Therefore, within the “Better Housing System” work package, the focus was on improving ventilation and roofing, other ways to improve cow cooling, and on better barn design. The following subsections give a quick overview of recent findings in each area. For more information related reports are available for further reference.

Ventilation

The thesis work of Lars Hummel, Bachelor student at the Industrial Product Design school of Saxion University of Applied Sciences in Enschede, the Netherlands, was about increasing cow comfort in dairy farm barns in the Pune district in India. These are some of the conclusions of this thesis work:

- “The barns do not offer enough for the cows to let them stay within their comfort zone. Most barns have a low roof that is plated with poor-insulating materials. Just below the roof in the barn, a lot of heat and moistures in the air is trapped and the cows are very close to that area because of the low roof. In barns like this, the cows are in fact only protected from rain and direct sunlight.”
- “To take away the heat stress, cows need to be cooled and the moist and warm air surrounding the cows and trapped under the (low) roof should go away. Because most stables have an open structure, forced-cooling is not an option because the cool air can easily slip away through the open walls. What can be done is to lower the cows’ temperature using the wind-chill effect. How much the temperature drops depends on the speed of the air circulating around the cow. This moving air at the same time takes away moisture and warm air that surrounds the cow and, with that, also lowers the risk of infections. A constant speed of 1.5 m/s is sufficient enough already to keep cows in their comfort zone most of the year. However, there is not much natural wind in the Pune district throughout the year, so the air movement must be created artificially.”
- “From several possible solutions, amongst others inspired by existing products, three designs emerged. One design was air blowing fences that should be put between cows. The second idea was about a block made of a material that would collect warmth over the day and gets cooled overnight. The third idea was to make a duct-like system that hangs under the roof of the barn and that takes in air from the outside and releases it inside the barn along the cows: see the right image of Figure 6.”
- “This third option was chosen to be further designed because of a better return on investment and because it was attractive to actual farmers that are part of the main RAAK project. Because of the low investment effort and the low maintenance effort, it will be easier to convince people to buy and use this. The product itself shows to farmers how easy it is to increase milk production and at the same time prepares them to change their expending moral.”



- “Theoretically between 25 and 40% of increase in milk production can be achieved, but no tests were done yet to actually prove that.”



Figure 6: Sketch demonstrating ventilation duct and its effect on cow cooling zone.

Roofing

As mentioned before, one of the strategies to combat heat stress is a better barn climate. An improved heat dissipation depends on the temperature difference between a cow and the surrounding environment, including air flow and heat transfer due to solar radiation. Heat transfer occurs in general by three mechanisms: conduction, convection, and radiation. Conduction is the transfer of energy through matter from particle to particle via molecular collision, as occurring in the warmed roof material. Convection is heat transfer by the actual movement of warmed matter, like warm air. The sun is a good example of heat radiation that transfers heat across the solar system. The ability of a material to radiate energy is called emissivity ϵ . Perfect reflectors have an ϵ of 0 and perfect absorbers an ϵ of 1. A material with a high emissivity is efficient in both absorbing radiation energy as well as emitting it. Therefore, a good absorber is also a good emitter. It can be seen from Table 6 that metals are, compared to asbestos cement and composite materials, good reflectors. However, the emissivity of a surface can be modified using low-solar gain coatings, which can have values of 0.04.

Table 6:
Material properties of various roofing materials.

Material	Emissivity	Thermal conductivity (W/(mK))	Density (kg/m ³)	Modulus (GPa)
Steel	0.23	43	7850	210
Aluminium	0.09	220	2707	69
Tin	0.05	64	7304	47
Concrete	0.85	0.7	2400	17
Clay	0.91	0.6	2000	3
Asbestos cement	0.96	0.166	1600	21.5
Fibreglass*	0.75	0.04	2000	12.6
Cotton cloth (Canvas)	0.77	0.04	1550	5
Glass wool	-	0.035	32	0.0032
PS foam	-	0.03	28	0.0034

*Quasi-isotropic, $V_f = 40\%$

Elementary heat transfer simulations were used to analyse qualitatively the effect of different roof and barn designs on the barn climate. The initial barn design is based on the 200-litre farm of Mr. Barge. The width is about 9 m, the outer barn height is about 2.50 m, and the roof pitch is about 3°, as shown in Figure 7(a). The roof is made of tin. The initial environmental temperature was set to 40°C. A vertical solar radiation was applied. The following design parameters were modified:

- Roof pitch α : Change from 3° to 22°
- Roof height: Change from 2.50 m to 4.00 m
- Roof shape: Change from closed roof to open structure with offset so-called “saddle roof”
- Roof thickness: Change from 15 mm to 100 mm

It can be seen from Figure 7(a) and (b) that by changing the roof pitch and increasing the roof centre height the temperature in the middle of the barn can be reduced. From Figure 7(c) it can be concluded that by lifting the entire roof the barn climate can be improved in the entire barn. As shown in Figure 7(d) an opening in the roof (saddle roofing) enables trapped warm air to escape and the barn temperature can be decreased. Figure 7(e) shows that a thicker roof structure impedes thermal conduction so that the temperature can be reduced. Moreover, it can be seen from Figure 7(f) that dependent on the fan power and position ventilation can decrease the barn temperature distinctly.

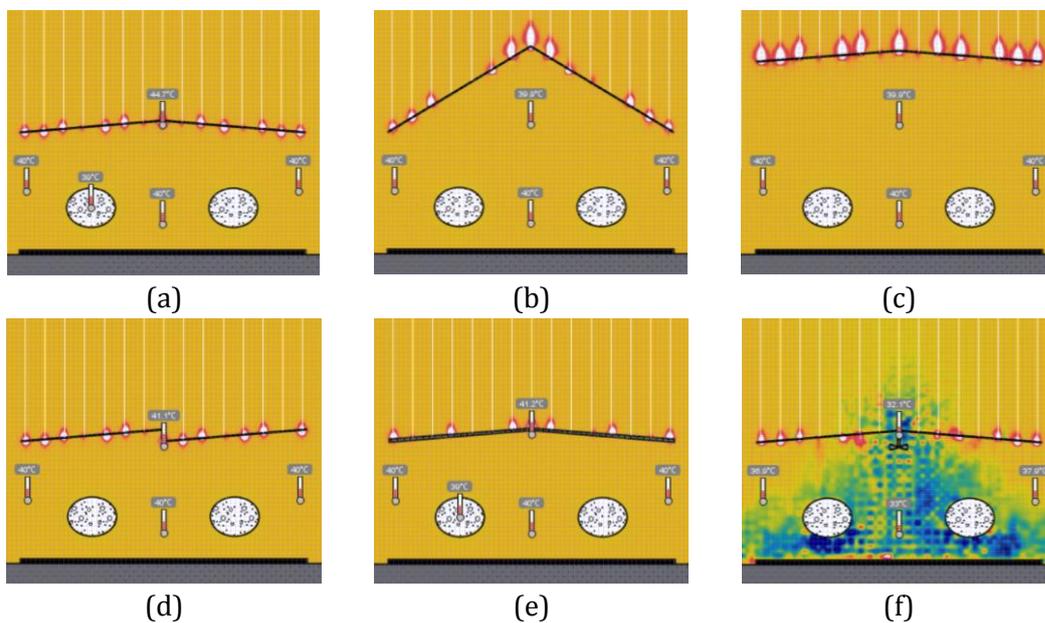


Figure 7: Results of heat transfer simulations for different design parameters.

Additionally, the heat flow Q was analytically calculated to determine the insulation effect of different materials by using material data listed in Table 6. In general, the lower the heat flow, the better a material insulates from heat. In order to compare different materials, such as metals and composites, with respect to insulation and lightweight a 1 m² big panel



was uniformly loaded with 700 N, which corresponds to a mass of about 70 kg. To obtain the same mechanical performance in the form of the same deflection, the panel thickness was determined and hence the mass of each panel. The outside temperature was set to 40°C and the inside temperature to 25°C. Figure 8 presents the results for different single material sheets. It can be seen that in order to bear the same load, the thickness of composite materials in comparison to metals has to be increased. Nevertheless, the mass can be decreased. Moreover, it can be seen that the heat flow is lowest for fibreglass (insulated sandwich structure) and thick canvas (cotton cloth).

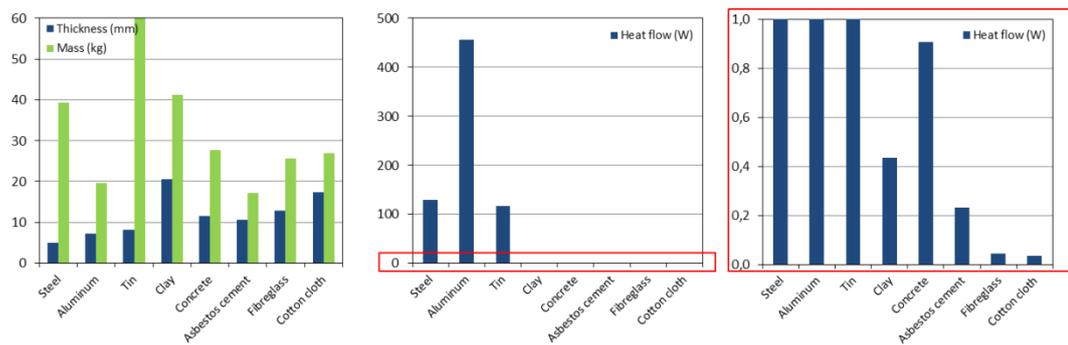


Figure 8: Thickness, mass and heat flows of different single material sheets.

In the second step, the calculations were repeated for different sandwich structures, namely aluminium (Alu) or fibreglass (FG) sheets with a core made of polystyrene (PS) or glass wool. The sheet thickness was assumed to be 2 mm, while the thickness of the core was determined. It can be seen in Figure 9 that the overall thickness of the composite structures is increased. However, the mass as well as the heat flow, particularly for the fibreglass sandwich structures, can be distinctly decreased. The results are substantiating that the sheet material as well as the outside material of a composite structure should have a low-thermal conductivity.

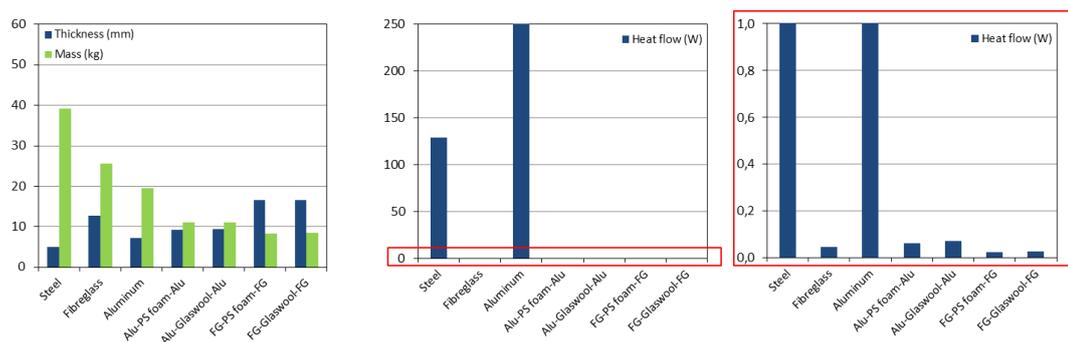


Figure 9: Thickness, mass and heat flows of different sandwich structures compared to single material sheets.



To conclude, there are several alternative roofing materials that are suitable for barns in the Pune district. These materials are:

- a) insulated sandwich structures made of fibreglass or aluminium sheet with polystyrene foam;
- b) composite materials and
- c) canvas materials that could be made of natural or synthetic materials.

A final heat transfer simulation was performed for a barn containing all modified parameters; open roof structure with an outer barn height of 4 m and a pitch of 15°, thick roofing made of fibreglass and ventilation. It can be seen in Figure 10 that the temperature can be clearly reduced in comparison to the initial design (Figure 7(a)).

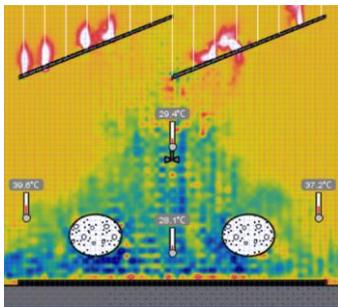


Figure 10: Heat transfer simulation result for modified barn.

Design 2.0: Traditional new barn design

We used a systematic approach to develop a new barn design suitable for mid-size dairy farmers (up to 500 litre milk production per day per farm). This development started out with the creation of a list of key requirements by the local farmers and dairy experts:

- The barn should sustain the climate conditions of Central India: monsoon (rain for 2 to 3 months) and extreme summer (up to 45°C);
- The barn should be expandable in the future;
- The barn should provide adequate cow comfort;
- Manure should be easy to handle;
- The barn should have a facility to harvest water;
- Electricity use should be as low as possible;
- Return on investment should be within a short period of time;
- It should be less labour intensive;
- The barn should be cost efficient.

These requirements were compared with existing barn designs available at GEA and Vetvice (suitable for Kenya). Both the GEA and Kenya designs were not suitable for climatic conditions in the Pune district. The GEA designs were targeted to European farms. The Kenya design was made for a dry climate (not considering a rainy season). Finally, Barn Design 1.0 was developed by Naresh Kondala considering most of the key requirements listed above. Design 1.0 also considered the possibility of an extra vermicompost plant with the manure produced locally to generate extra money. In a later stage, Barn Design 1.0 was further



discussed with the local farmers and dairy experts during the April 2017 workshop conducted at ADT Baramati, India. Additionally, during the last year, new solutions on how to deal with heat stress in the barn have been developed at Saxion. Therefore, it was decided to redesign the barn by integrating newly developed know-how: Barn Design 2.0. The front view of this new barn is shown in Figure 11.

Some assumptions were considered for Design 2.0. The barn is suitable for a milk production of 500 litre/day. Assuming an average 20 litre/day milk production per cow, the estimated number of milking cows is 25. With 70% milking efficiency and with some calves we anticipate a barn for around 40 animals. An average space of 15 m² per cow was considered (incorporating the free walking barn concept). With 20 animals on each side of the barn and extra space for the bulk cooling unit as well as an office, the anticipated size of the barn is roughly 30 x 35 m. For the outside free area, an extra width of 10-15m on each side is considered. The Design 2.0 has the following key features:

- **Barn direction:** The front of the barn faces North. This means that the milking cows (on the left side of the barn) get early morning sunlight. Between 10:00 am till 4:00 pm, the sun will not enter the barn: the cows are always in the shade.
- **Roof:** The roof height is 4.0 m on both sides. There is a primary and a secondary roof cap planned to ventilate the hot air generated inside the barn and to circulate the fresh air.
- **Water harvesting:** The roofing is at a 15° pitch to allow rain to flow easily to water harvesting channels, which then lead this water to the water storage at the back side of the barn. The roofing material is made of an insulating sandwich material or made of a composite material.
- **Energy harvesting:** Solar panels are placed on both sides of the roof to maximise the collection of solar energy. The placing of solar panels should also consider the shading created by other objects.
- **Heat regulation:** Key equipment such as foggers or sprinklers together with fans are installed to maintain the desired humidity and temperature. Solar power is used to run these devices.
- **Central feed alley:** The 6.5 m wide central feed alley is around 23 cm high, so that cows have easy access to the fodder. A wide feed alley allows a tractor to distribute the feed and to reduce the manual labour.
- **Cow position:** The cow alley has a 2 to 4° slope towards a gutter for easy flow of excretion such as urine or manure. No cubical and side bars are planned since that requires a lot of maintenance and has high investment costs.
- **Open bedding:** Next to the gutter, the barn will have an about 6.5 m wide straw bedding for optimal comfort.
- **Outside barn area:** At both sides of the barn, there will be sufficient open area for the cow with tree plantation for shade. During the summer time, the open area can also be covered with a 90% closed shed net to prevent direct sunlight but allowing fresh air.
- **Shading:** A 90% closed UV-blocking polypropylene (PP) net can be used to temporarily create shade on both sides of the barn.



- **Other optional devices** according to the individual requirements are a milking parlour, a bulk cooling unit, a milk pasteurizing unit, etc.
- **Extra:** As proposed in Design 1.0 it is still possible to extend the barn with a vermicomposting plant for extra financial benefit. The same tractor can also be used as a cow dung scrubber to collect for the vermicomposting plant.

Note: Not all specifications are given, since this new barn design can be adapted to the needs and possibilities of the individual farmer's requirements (availability of land, investment capacity, herd size, etc.).

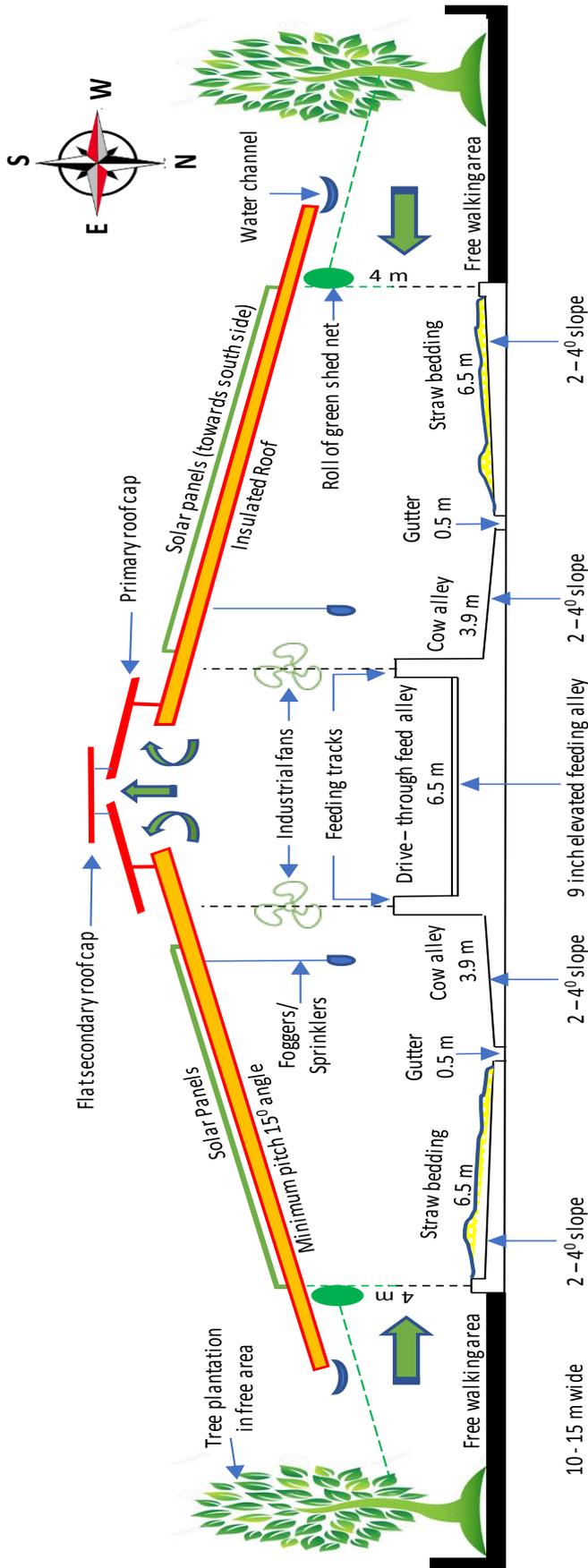


Figure 11: Barn Design 2.0 with the key features.

Design 3.0: Next generation barn design

Tom Kruiper, Joris Boomkamp and Tjerk te Dorsthorst are Bachelor students from the Building Construction school of Saxion University of Applied Science in Enschede, the Netherlands. As part of their minor 'Industrial Building' the students participated in the Dairy Wikihouse India project. Their assignment was to design a Wikihouse-type barn for dairy farms in the Pune district. In their Executive Summary, the following was reported:

- "While the focus is on designing a new barn, several issues are taken into account like drinking water supply and distribution, fodder supply and distribution, surrounding area of the cows, and the way the barn is constructed and build. When all of these issues are handled, the assumption is that the welfare of the cow will increase resulting in higher milk production which will in turn have its effect on the (economic) welfare of the farmer."
- "The resulting barn is modular (Figure 12) and has a saw-tooth roof (saddle roof), open at one end so that moisture and warm air can easily escape the barn (Figure 13). The barn has to be located in such way that no rain can enter through the opening in the roof. The roof is lightweight because it uses canvas as roofing material. Canvas can easily be protected from different weather conditions (rain, sun, moisture). What is also different compared to most of the farms today is that the roof is higher: the top is at 4 m. Because of this, the heat radiated by the cows is trapped much higher resulting in a lower temperature at ground and cow level."

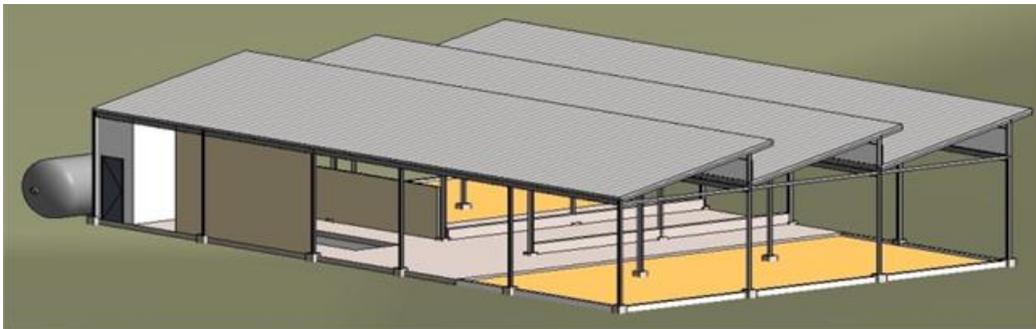


Figure 12: Sketch of two-sided modular saddle roof barn.

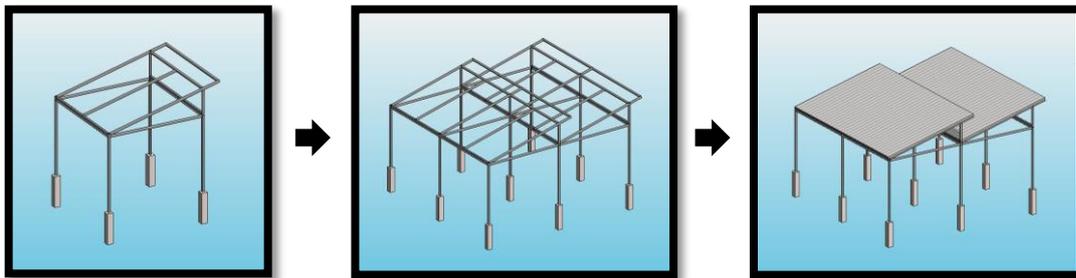


Figure 13: Modular barn with saddle shaped canvas roof.



- “Although the project started with the Wikihouse concept in mind, only part of the Wikihouse elements are incorporated in the design. The barn can be built with local materials (concrete, aluminium/steel, canvas). The barn is also designed in a modular way, making it easy to extend to cater for more cows. One of the key features of the design presented is that it is possible to have a large but roofed free walk area for the cows.”

Conclusions and recommendations

The key issues related to heat stress in the barn can be coped with by increasing the ventilation, by preventing direct sunlight to fall on the cows, and by minimising the roof radiation. Table 7 shows both short- and long-term investment solutions.

Challenges in the barn	Existing situation	Short term low investment (Design 2.0)	Long term high investment (Design 3.0)
Poor ventilation	<ul style="list-style-type: none"> • Some barns have foggers 	<ul style="list-style-type: none"> • Installation of fans • Installations of foggers/sprinklers 	<ul style="list-style-type: none"> • Increase the barn height: up to 4 m on sides with a 15° pitch, preferably with a secondary roof cap (Figure 5) • Open roof structure
Costs	<ul style="list-style-type: none"> • ± € 70 	<ul style="list-style-type: none"> • Fan ± € 80 per unit • Foggers ± € 70 	<ul style="list-style-type: none"> • Extra material ± € 2000-2500
Direct Sun light	<ul style="list-style-type: none"> • No action 	<ul style="list-style-type: none"> • Installation of temporary synthetic PP shed net (90% closed structure) 	<ul style="list-style-type: none"> • Wider and higher roof structure with 15° tilt
Costs	<ul style="list-style-type: none"> • No extra cost 	<ul style="list-style-type: none"> • Shed net ± 80 Euros 	<ul style="list-style-type: none"> • Shed net curtains • See extra material cost above
Roofing	<ul style="list-style-type: none"> • Tin metal: highly conductive • Asbestos cement: carcinogenic 	<ul style="list-style-type: none"> • Putting green/dry straw on top of the tin roof. However, the metal roof might corrode. • White paint/ low-solar gain coatings on outer side of the metal roof 	<ul style="list-style-type: none"> • Lightweight insulating roofing materials such as <ol style="list-style-type: none"> a) sandwich structures, b) composite panels, or c) UV-blocking waterproof canvas



Costs	<ul style="list-style-type: none"> For 30 years around € 4 per m² 	<ul style="list-style-type: none"> For 30 years around € 6 per m² 	<ul style="list-style-type: none"> For 30 years around € 6 per m²
Cow bedding	<ul style="list-style-type: none"> Wet and slippery concrete floor causing skin rashes 	<ul style="list-style-type: none"> Inclined (soft) concrete floor next to central feed alley and straw bedding No cubical or side bar 	<ul style="list-style-type: none"> Open multilayer soft flooring that allows urine to drain (Barn Design 3.0)
Costs	<ul style="list-style-type: none"> No extra investment 	<ul style="list-style-type: none"> No extra investment 	<ul style="list-style-type: none"> Around € 20 per m²
Access to feed and water	<ul style="list-style-type: none"> In partial tied barn system, cows get feed and water twice per day: malnutrition 	<ul style="list-style-type: none"> Balanced feed should be accessible all the time Water tank can be painted with CaCO₃ to prevent algae growth and for extra Calcium supplement 	<ul style="list-style-type: none"> Wider central alley, where feed can be distributed with tractor Access to clean water all the time
Other costs	<ul style="list-style-type: none"> Extra labour cost 	<ul style="list-style-type: none"> Extra cost for balanced feed and labour 	<ul style="list-style-type: none"> Tractor: around € 10.000 Tractor can be used for cow dung scraping, vermi-compost plant and other business activities on the farm.
Energy	<ul style="list-style-type: none"> Standard electricity € 0.13 per Unit 	<ul style="list-style-type: none"> Extra electricity per industrial fan: extra consumption up to 5 Units per day 	<ul style="list-style-type: none"> Solar panels investment ± € 3200 (No extra electricity cost)

Several short- and long-term solutions have been described in this report. To sum up there are multiple solutions possible to deal with heat stress and allow for a better stable management. It all starts with the list of requirements of an individual farmer and the financial freedom for investments to make the barn more comfortable for the cows and hence increase their productivity.



Box 1: Innovation in barn design.

Revenue

A better barn design can lead to a lower temperature in the barn (especially during the hot season of 6 months during Feb-July each year), less heat stress for the cattle and a higher milk production.

Considering an Indian farmer with:

- 21 cows, each producing 12 liters milk and producing 300 days every year
- A milk price of INR 23 (€ 0,30) *
- An expected increase in milk production of 20% (40% during half the production period)

The additional revenue will be: $21 \times 12 \times 300 \times \text{INR } 23 \times 20\% = \text{INR } 3,49,272$ (€ 4.536,-) per year.

Costs & investment

To be able to create a new barn, based on the innovative barn design, extra investments are necessary. Investments have to be made in:

- The base (concrete) & the roof (roof: $600 \text{ m}^2 \times \text{INR } 462$; base: $600 \text{ m}^2 \times \text{INR } 462$;-; total: INR 5,54,400 (€ 7.200,-)
- Cooling fans, foggers & light (fans: $12 \times \text{INR } 7,700,-$; foggers: $5 \times \text{INR } 7,700,-$; light: INR 7,700; total :INR 1,38,600 (€ 1.800,-)
- Solar panels, to generate electricity INR 3,08,000 (€ 4.000,-).

For a total amount of INR 10,01,000 (€ 13.000,-)

Since the electricity is generated by solar panels, there are no additional annual costs. Additional costs for acquiring a tractor, chaff cutter, bulk cooling unit and milking unit have not been taken in consideration, since this investment is not a necessary condition for a better barn design. Would a farmer want to invest in this additional machinery, the investment would be INR 7,70,000 (€ 10.000,-).

Benefit & return on investment

When investing in a new barn design creates an extra annual revenue of INR 3,49,272 (€ 4.536,-) per year. The return on investment is 33% (INR 3,49,272 minus INR 10,010 depreciation/INR 10,01,000).

Other, more or less non-financial results are:

- Improvement of animal health and welfare (less heat stress, better living environment).
- Improvement of employee satisfaction (better working conditions).

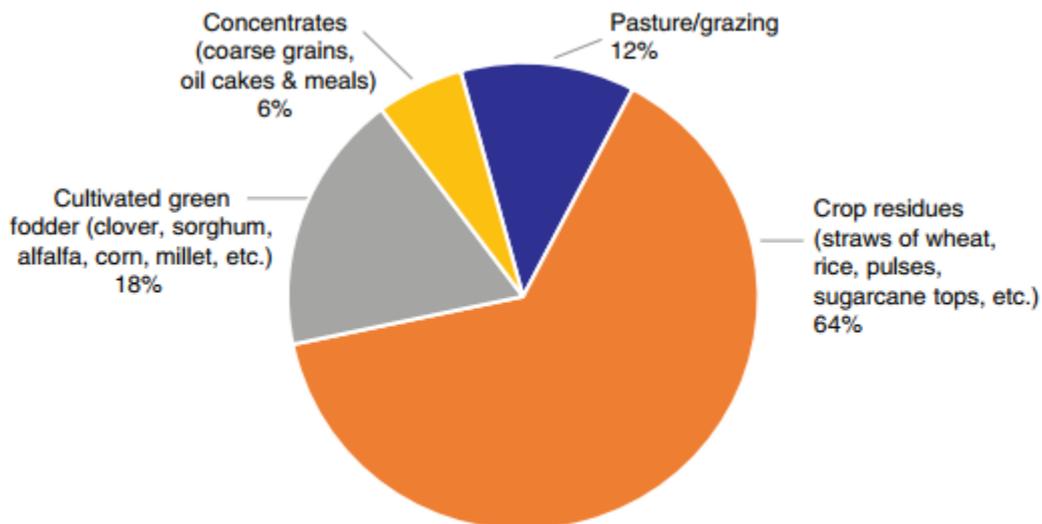
* Exchange rate 25 September 2017 € 1 = INR 77



3.2 Innovations in feed and silage

Dairy animals in the Baramati region have a low productivity and do not follow the optimal lactation curve. Nutrition is one of many issues causing this, but a very important one. Farmers connected to the FDT project mentioned it as the main problem they have to deal with in day to day farming practice. There is common awareness, also by these farmers, that only by maintaining proper quantities and quality of feed cows are able to produce up to the expectations.

Currently farmers do not have any particular set ration which will fulfil the need of milking cows for higher milk production. Furthermore, farmers have to face green fodder shortage during the summer period. During this period animals are fed with the crop residues such as wheat straws, sugarcane tops, etc. Feed intake during this period cannot be evaluated as no records are kept. So, all together the farmers face problems of no proper ration, feed shortage, low milk production and feeling that they have a lack of options for maintaining good nutrition for the animals. The composition of feed supply in India is shown in figure 14.



Note: Percentages of total feed supply on a dry matter basis.
Source: USDA, Economic Research Service. Government of India, Planning Commission, 2012.

Figure 14: Composition of feed supply in India.

In Pune region summer period is considered as the months of March, April, May and June. It is followed by the monsoon season or rainy season up to the month of October. The period from November till March is called the winter season, with moderate temperature and very little rain. In very well irrigated areas three crops can be produced, however in many places they only produce one crop in the rainy season.

Because only a small portion of animal feed in Baramati region is produced by the farmers themselves, the farmers depend largely on seasonal offer of the industrial feed producers and local vendors. This results in fluctuations in availability and prices. It is expected that when farming practices, industries and markets are better organised that optimal milk production in this region can easily increase up to the level of 15 to 20 kg per



crossbred HF cow per day during the cow's productive lifespan at the dairy farm. However, the problem with feeding and digestion in ruminants is that it is connected with complicated physiological systems interacting with many environmental factors.

To solve animal feeding problems in the most cost effective way, farmers have to combine structural and short term solutions. Short term solutions focus on more economic thinking behind decisions making questions, keeping the focus on the animal needs and production system. I.e. what are acceptable prices and qualities, how to store the feed, how to feed the animals and how to take care for good water supply to the animals? Structural solutions refer to investments in machineries or equipment for harvesting, storage and handling of forage and feed, but also to land use planning and forage growing, applying proper feed planning tools and having a long term management perspective.

At the moment very simple methods, tools and machinery are applied. New animal nutrition practices have to be developed, fitting in local circumstances, applied by local farmers and supported by local industry and knowledge suppliers. Within the framework of this project only small steps can be made.

After the workshop week in India, March 2016, Dutch and Indian researchers and entrepreneurs concluded that the main focus regarding animal feed related product and service development should be on quality control, feed advice, machinery and storage techniques for silage. Regarding these three subjects, in depth investigation has been done:

- identification of potentials for improvement of farming practices, creating more understanding for all stakeholders (Dimitra Giannakopoulou);
- developing new systems for making rations, including feed quality evaluation, helping farmers making better decisions regarding feeding and acquiring fodder (Ashwin Ladhe);
- feasibility study for setting up a maize silage production line for individual smaller farmers by the feed company Baramati Agro (Andrea Hulleman).

Identification of potentials for improvement of farming practices

From the perspective of internationally accepted dairy farming practices a farm manager has to apply the following five principles to his feeding practices (Ten Berge, 2014):

1. Evaluate the effect of the applied feed system in milk production records
2. Understand nutritional requirements of the animals
3. Make feed provision plans and having good quality feed available
4. Apply daily rationing and check the feed and water intake
5. Check rumination, digestion, manure, health and growth of the animal

To make serious progress in improving feeding the farm manager has to formulate an action plan for each of the five principles. They can lead to both short term solutions and structural solutions.

An animal nutrition handbook has been developed in this project, supporting farm managers and feed advisors developing their plans (Giannakopoulou, 2017) This handbook can also be used for students, junior advisors and managers helping to understand backgrounds of animal nutrition principles. It follows and applies general management principles towards practical animal nutrition and combines theoretical knowledge with practical knowledge and observations. It is exactly this integrated and problem based approach that is lacking in Indian animal husbandry at this moment. Nowadays specialists



have theoretical knowledge and most often are not able to bridge the gap between theory and practice. A complicating aspect in this is that the theoretical knowledge and concepts are mostly based on large scale farming in controlled circumstances.

In the specialist workshop in April 2017 with specialists of Baramati Agro and KVK, staff and students of the College of Animal Husbandry and Van Hall Larenstein, it was concluded that the following issues are mainly at stake in better feeding of dairy animals:

- provision of protein/nitrogen rich components in the rations;
- profitable organization of technology in silage production;
- new practical methods of ration formulation;
- new crop varieties to be introduced in the region;
- possibilities to increase regional fodder production;
- practical solutions for water provision of animals;
- economic approach to young stock rearing at the farms.

It is important to be aware that those issues require specific analysis of strategies of groups of farmers in the framework of connected industries and knowledge networks. The College of Animal Husbandry in Baramati can play an important role in that.

Evaluating feed quality evaluation and ration calculation systems

In 2017, Ashwin Ladhe investigated possibilities to implement a new feed quality assessment system and to come up with improved methods for rationing, the possible role of Eurofins Agro and Baramati Agro company are taken into consideration in this.

At present rationing is basically done on quantity of feed, where feed is categorised as dry fodder, green fodder and concentrates. Dry fodder contains very low amounts of digestible energy and protein but creates a high level of rumen fill. When compensated with appropriate concentrates and green fodder it is a very good component of the ration. Green fodder includes silage, the energy and protein depends on the type of crop and growing stage at harvesting. Nowadays at the family farms in the project, rations are determined based on availability of affordable feed. The green- and dry fodder rations are topped up with additional standard concentrates for dairy cattle or singular concentrate-like products as cotton seed cake, supplied by companies like Baramati Agro. Rations were not specified up to the individual level of the animal. There is no control over the water quality. Farmer do not keep any feeding records and feed analysis reports. Most of the farmers do not have an agricultural education so they do not know a lot about the modern ways of dairy management and feeding. Only the KVK dairy farm is producing their own silage to use in the shortage period. Rest of the farmers have very limited availability of feed.

Nutritional requirements and feed quality evaluation is performed in the Netherlands, and used by Eurofins Agro, based on the 'Net Energy Fodder Units Milk' (VEM) and 'Ileal Digestible Protein' (DVE/OEB) system. The system is based on requirements of energy and protein for milk production and is taking the physiologic and metabolic impact of feed into account. The Indian system used by Baramati Agro for energy and protein evaluation is TDN (Total Digestible Nutrient) and CP (crude protein). In the TDN, none of the energy or protein losses are taken into account, except faecal losses. The outcomes of the Dutch and Indian systems calculating the needs of the animals are different. In the research both systems were compared towards its practical use in the target group of farmers.



Firstly, the energy and protein needs of the animal during the different stages of life such as calves, heifer, lactating and dry cow were calculated based on the formulas of the Dutch and Indian system, with focus on the productive dairy cows. Secondly, information was gathered about the present rations and feedstuff which were fed to animals of some pilot farms. Also feed samples were collected from those pilot farms and analysed by Eurofins-Agro in the Netherlands according to Dutch feed analysis system.

After formulating the rations for three farms it shows that the main problem is not the type of system that is applied, but the main thing which matters is assessing the quality of feed. At the moment the TDN/CP system is appropriate, but has to be applied in a more systematic way following the five steps presented before.

Rationing has to start with understanding and reaching the energy and protein requirement of the animal, but a critical control point for reaching the required energy and protein intake is the Dry Matter Intake (DMI) of feed. The DMI should be at least 11 kg according to the general thumb rule of 2-3% of the bodyweight (Weiss, n.d.). Feed cost are less if the DMI increases because greater DMI means that nutrient concentration in diet can be reduced to maintain intake of specific nutrients. If DMI is inadequate by diet or management, body fat as energy stores are depleted and milk yield will drop to match dietary supply of energy (Weiss, n.d.). Moulded and spoiled feed also decreases the DMI and ration design cannot overcome this problem. DMI is also reduced, if there is a very high fibre concentrate in the diet as it reduces speed of fermentation and the cow requires more time for rumination (Cooper, 2017). It is advisable that Dutch indicators as Fill Value and Structure Value are taken into consideration in rationing.

Interviews were carried out to find opportunities for services for feed quality analysis. The Baramati-Agro company is already providing feed analysis facilities to the dairy farmers for free, but very few farmers are taking advantage of it. This means that the farmers either are not aware of the advantages or do not want to carry out the analysis. It can be concluded that first the advisory system on production measurement, rationing, feed planning, feeding and animal control has to be in place before advanced systems, like those of Eurofins Agro, are introduced.

Feed advisors, by feed companies and/or (para-)veterinarians have to use simple ration calculation tools to motivate the farmer in quantification, recording and evaluation of practices. Advisors have to develop a simple advice base through which the progress of the applied methodology can be shown to the farmers. Especially when the knowledge of farmers in this field is lacking extra attention should be paid to the relationship between farmer and advisor, because both of them are in transition and learning in what way to make use of the integrated approach.

Feasibility study for setting up a maize silage production line

The scarcity of good quality roughage supply, especially in the summer, is one of the main reasons for low milk production levels. The question is if local produced maize silage could fill this gap. Maize is a common, easy to handle and good quality crop. The possibilities for Baramati Agro to organise this was investigated. Analysed are the demand of the farmers in terms of preferences and expectations on the maize silage, but also the system how the maize could be brought to the farmers was investigated. The research data about the expectations and the preferences of the farmers were collected by doing four interviews with



farmers and a survey among 178 dairy farmers. The survey and interviews were conducted in Pune district from 13th March until 7th April 2017. The survey was held by five Bulk Milk Collection (BMC) centres.

Based on the research it was concluded that maize silage can cover the energy needs of the dairy cattle, but attention has to be paid to the quality of maize, water supply and the whole ration with special attention for covering the protein requirement. Looking at the type of maize silage it was concluded that silage in bales or bags are the best options. The choice depends on the risk for damaging the plastics, operational costs, investment, practical usability and acceptance by the farmers. It is likely that bales will be the best solution.

The total estimated demand of maize silage according to the survey in the summer is 66%, this results in a total of 104 farmers who are interested in silage. The average amount of cows per farm is 7, so an estimated 462 cows in total need to be feed with silage. The average amount of silage farmers would like to feed is 6,7 kg of maize silage per cow per day. This results in a total demand of maize silage $6,7 \times 7 = 47$ kg per farm per day. This is a total estimated demand of 3,100 kg of maize silage per day. The summer period in Baramati is only about 4 months per year.

About 40% of the farmers thought that maize silage is improving the milk production. Mostly they expect an increase with 2 litres per animal per day. About 2% of the farmers in the survey did not expect an increase in milk production, where more than half of the farmers (58%) said they do not know if it will increase. The survey showed that 66% of the farmers want to buy maize silage during the summer period. As mentioned during the interviews farmers are struggling with animal health issues such as worms and a loss of body weight. This can be a result of having scarcity of feed during the summer period. This will lead to a decreased milk yield of about 5-6 litres per cow per day. So we can conclude that the need of maize silage in summer is high. Farmers who are already using maize silage are very positive about maize silage as they will get a higher milk yield.

Impact and investments of improved feed and silage handling

A rough estimate of the price of one bale of maize silage of 1000 kg is 3000 INR. The costs for Baramati Agro to produce a bale of maize is estimated at 2500 INR. The return on investment for a farmer for buying one bale of maize depends on the increase in milk production that the farmer will be able to establish. As one cow will eat approx. 20 kg of maize silage a day this will cost 60 INR. At a milk price of 20 INR per litre at least an increase in milk production of 3 litres per cow per day is required. If the milk production level increases with 6 litres per day the marginal cost related to feeding for this 6 litres of milk are 10 INR per litre extra milk.

The survey showed that farmers are interested in silage, but 37% do not want to pay more than 1000 INR per ton, 22% want to pay between 1000 and 2000 INR and 21% between 2000 and 3000 INR, only 4% answered that they are willing to pay more than 3000 INR (figure 15). In conclusion, the farmers are not yet willing to pay the calculated production costs of the maize silage bales.

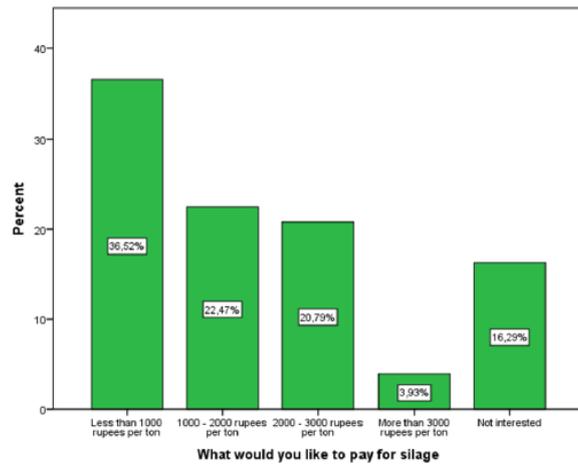


Figure 15: Prices farmers are willing to pay for maize silage.

At this moment some farmers try to make silage themselves but the process of making silage is hard to manage and often results in a bad quality of maize silage (moulded maize). A handful of farmers already produce good quality maize silage. This attracts the attention of their neighbours, because they see milk production increasing, which is making them curious about feeding maize silage. But not only the maize silage production process is an issue, also the investment to store maize silage for example in an bunker silo prevents farmers to start feeding maize silage. In fact Baramati Agro is taking over the main required investment by buying the bailer machine and other required mechanisation. Another advantage is that bales are easy to transport so this is a good manner to make the sales area wider spread. In this way also regions with less availability of irrigated land can benefit. According to the survey and interviews most farmers want to grow in the amount of cows they keep. This will increase the demand for maize silage.

For Baramati Agro promotion will be helpful to sell maize silage bales. Taking into account what information farmers want to be able to make decisions, some suggestions are:

- Give demonstrations of making bales and what maize silage looks like when it is ready to feed;
- Organize feed trails where some cows get maize silage and some do not;
- Make simple information leaflets or instructive posters about maize silage and the profits of silage in bales;
- Make videos of experienced farmers telling their success stories.

The introduction of maize silage can become more attractive to the farmers depending on the role of government subsidy programs, how processors can benefit and how the scale of operations can grow fast. Overall there is a big chance of success because introducing silage as a profitable feed system makes better quality of feed available during the whole year, leading to a more constant good quality milk flow. The main risk will be availability of land suitable for maize production and the competition between land use for cattle feed and human food production. Apart from social, economic and political factors the availability of water resources, land use and top soil management practices are important factors.



Box 2: Innovation in feed and silage.

Revenue

Better feeding of the animals, with maize silage, will improve the quantity and quality of milk production during the period of food shortage (100 days per year). The estimated extra production is 4 liters per cow, per day, during the period of food shortage (100 days). Considering an Indian farmer with:

- 21 cows, each producing 12 liters milk and producing 300 days every year;
- A milk price of INR 23 (€ 0,30)*;
- An expected increase in milk production of 4 liters per cow, per day.

The additional revenue will be: $21 \times 4 \text{ L} \times 100 \times \text{INR } 23 = \text{INR } 1,94,040$ (€ 2.520,-) per year.

Costs & investment

A farmer can invest in a tractor or a feeding robot, but this is not a requirement for better feeding. Investments have to be done in a chopping machine and creating a storage for the silage. The assumption is that a farmer already possesses a chopping machine (for example for cutting the sugar cane) and creating a (pit) storage can be done without substantial extra investments. To improve the feeding, expenses have to be made for buying maize bales:

- A farm with 21 cows would need $21 \times 20 \text{ kilo} = 420 \text{ kilo}$ per day. Considering that the extra feeding will only take place in the summer period (100 days) and the price of maize silage (INR 3/kilo) total additional costs are: $420 \times 100 \times \text{INR } 3 = 1,26,000$ (€ 1.635,-) per year.

Benefits & return on investment

Better feeding will create an extra annual benefit of INR 64,680 (€ 840,-) per year (for a farmer with a producing livestock of 21 cows). Furthermore there are benefits to be obtained, as:

- An improvement in animal health and welfare (better feeding).
- Improvement in milk quality.

** Exchange rate 25 September 2017 € 1 = INR 77*



3.3 Innovations in breeding and record keeping

In the workshop in March 2016 the FDT farmers all agreed that record keeping is most important for increasing profitability of dairy farming and dairy value chain development. Now only 2 of those farmers kept records on dairy production, one for breeding purposes and the other from a marketing perspective. Noted is individual cow production and general information on sales of milk. Generally speaking, the small and middle sized farms in India do not apply record keeping systems. Factors refraining farmers from record keeping are the illiteracy of farm workers and lack of knowledge and understanding on how to use the information for improving farming results. There are no relevant legal requirements for record keeping and in the region there are no ongoing governmental projects on dairy production record keeping.

Based on these findings in March 2016 it was decided that in the FDT project activities were performed to investigate how local record keeping programs could be organised, supporting farm development programs for breeding and dairy herd production management. There are three potential organisers of systematic local record keeping:

- farmers from the perspective of a joint breeding goal, supported by breeding organisations/specialists;
- dairy processors linked to the farmers, supported by Management Information System (MIS) services offering organizations;
- advisory or research services from the CoAH and the KVK.

Within the FDT consortium the possible implementation of two innovations have been investigated:

- Wytse Nauta Advice, jointly with support of CoAH, KVK and VHL, establishing a local Farmer's Dairy Breeding Association (FDDBA).
- Introducing Uniform Agri's App based Dairy Management Information System (Uniform Agri App).

In the FDT project potential users were confronted with these systems. Based on their feedback, future plans for implementation of both systems were developed. In this paragraph the systems and its backgrounds, the evaluation of the trial activities and the future plans are presented and discussed.

Farmer's Dairy Breeding Association (FDDBA)

Many Indian farmers are motivated to buy or breed a better cow, which is fertile, healthy, trouble free, having a high milk production and producing a good quality of milk. Currently in India, the indigenous milk producing breeds of cow produce less amount of milk as compared to exotic dairy cattle breeds. Therefore, the Indian indigenous breeds are crossbred with Holstein Friesian (HF) bulls in order to increase milk production. The HF crossbred cows are not performing optimally. Several reasons are responsible for low milk productivity per cow such as high temperature, faulty management practices, inefficient veterinary care and AI services, no record keeping, etc. (Kapoor, 2014).

Dairy cattle breeding is all about selecting the best animals (parents, in this perspective cows are called dams and bulls are called sires) producing a superior generation as compared to the parent generation of animals (Oldenbroek and van der Waaij, 2014).



The performance of the animal depends on its genetic potential, farm management practices and many other surrounding environment factors. To breed a better cow a breeder must select the best dams and sires from the population based on breeding goal. With that he has to focus on the genetic component of the performance. In dairy animal breeding it is very complicated to measure the genetic potential of the animal. There are many systems available around the world, all mainly depending on performance information from cows: production, fertility, health, conformation. Nowadays also information based on DNA analysis is used by international operation breeding organisations, but that information can only be used as additional information. It starts with understanding genetic differences between the cows in the farms herd for selecting the right parents for getting the best next generation.

In this FDT project a method was introduced to start up a milk production recording system for understanding the genetic potential of the herd. A very important side effect of introduction of such a system is that farmers can learn to understand the use and benefits of farm data for other farm management activities, especially related to health care, reproduction, fertility management and nutrition. Indirectly it can be a very motivating tool for creating higher farming profits.

To investigate the potentials and problems of implementation of the method, several activities were performed and monitored. From seven commercial farms and the KVK the system of monthly milk production recording from each cow was implemented, including sampling milk to analyse on fat, protein, lactose and SNF percentage. To introduce this, a cow identification system had to be implemented, including a registration system on reproduction and health data for each cow.

Production recording results reports on paper were given to and discussed with the farmer. Simple forms of recording fertility and health data were prepared. A business plan including proposed follow up activities were prepared for development of a data collection system for breeding purposes and a breeding system. To make the system working efficiently and sustainable, the possibilities of collaboration with KVK, AI agencies, National Dairy Development Board, Maharashtra Livestock Development Board, milk processors, breeding organisation, etc., were taken into consideration.

It was planned also to set up a breeding goal and breeding strategy for the participating dairy farmers. Two dairy farms have indigenous dairy cattle breed, mainly Gir (picture 14). Therefore, a pure breeding system for these two dairy farms should be formulated. Crossbreeding is greatly practiced to increase the milk production of dairy cows, but maintenance of certain crossbred percentage of exotic breed is very necessary. Upgrading with pure HF sire reduces the local breed percentage, which does not perform optimally in hot



Picture 14: Gir farm of Mr. Taware



climate with poor farm management. A further analysis of strategies is not possible at this moment due to lack of information and lack of commitment of farmers and organisations.

All the participating dairy farmers were interviewed about their opinion on development of a data collection system for breeding purposes. Dr Jalinder Kate, in charge of the artificial insemination centre of Baramati milk union, was interviewed for sire information and how do they maintain records of animals. Dr Khomane, an AI technician from private AI services, who does artificial insemination at Sachin Khalate dairy farm, was interviewed to understand how sires now are selected for insemination and which data are recorded. The director of Baramati Milk Union was interviewed to ask for his opinion on collaborations to start-up the data collection system. Dr Ratan Jadhav of KVK was also interviewed and discussed with in detail about opening a data collection system for breeding purposes in KVK. This resulted in the following main conclusions:

- a) Setting up a Farmer's Dairy Breeding Association (FDBA) can be successful if the following benefits of collaboration in this association are fully recognized by the participants:
 - Family farmers' breeding goal is leading
 - Having accurate and reliable breeding information.
 - Having good connection to knowledge institutes.
 - Accurate chain information is provided.
 - Developing a sustainable breeding organization and information exchange.
- b) The main information on traits that needs to be measured from the small and medium sized dairy farms for breeding purposes are: milk production, fertility, health data and body conformation of each individual dairy cow.
- c) The way farm data will be collected, managed and processed for breeding purposes in the first stage of implementation is:
 - *Data collection:* The data will be collected by filling in forms prepared for the required data. Once a month a data recorder will visit each dairy farm for milk recording and other data collection. The milk samples will be tested and written on a form.
 - *Data processing:* The collected data will be entered in MS Excel for data analysis. A detail report of each dairy farm's performance in terms of milk production, fertility and health will be prepared.
 - *Data management:* Once the data is processed, a dairy farmer will receive a report from a data recorder within 3-5 days. Another copy of a processed report will be stored in Google drive as a backup.
 - *Calculate breeding values:* Due to a lack of information on dairy cows' performance it is difficult to execute any of the breeding values calculations. In the first stage interpretation of animal data has to done by the farmer in collaboration with experts, mainly on focussing on selection of dams for calf selection.
- d) The Farmer's Dairy Breeding Association (FDBA) will monitor the progress of associated dairy farms within specific area of Pune district, formulate its breeding goal for breeding in its entire population and setup a breeding organisation. Data collection will help FDBA to identify the problem areas and advice dairy farmers to improve the milk yield as well as farm management practices of dairy farm. This will also educate the dairy farmers.



Involved in the action plan pilot phase have to be:

- Farmers, FDBA, WNA, KVK/CoAH.

Actions are improving methods for:

- Cow identification.
- Data collection and analysis.
- Data management.
- Farm specific breeding advices.
- Networking for further collaboration in the second phase.

Involved in the action plan picture next phase have to be:

- Farmers, FDBA, KVK/CoAH, milk processor, AI agency, ICT company e.g. Uniform Agri.

Actions:

- Creating a bigger group of farmers.
- Offering additional services and data related to milk processor.
- Development of breeding strategy for connected AI agency.
- Development of ICT system.

Uniform Agri's App based Dairy Management Information System

To analyse what exactly is happening in a dairy farm, it is important to have certain records kept. The farmers in India avoid records and depend on their own memory to store the farm information. Because the memory vanishes after some days this will lead to improper production and health analysis of the dairy cows. Farmers are not aware of the real strengths and weaknesses in their farms. This subsequently affects the economy of the farm. If farmers do keep records, they will get a good grip on managing their own farms records, and they will know how well they are managing their dairy farm in comparison with other farms. For dairy farmers that want to grow their farming business and borrow money, it is very imperative to have precise facts and figures (Rajalaxmi Behera, Ajoy Manda, Adhikari Sahu, 2017).

Uniform-Agri management software is offering analysis tools through which farmers can improve their farm practices and improve the production and health analysis. In their product portfolio they have desktop based systems for middle size and larger farms, they are used by farms with approx. 70 productive cows. On top of the desktop system a Multiple Farm Solution was developed through which indicators of different farmers are compared and an app for smartphones that communicate with the desktop system. Recently a new app based system for small farmers has been developed. In that system the Multiple Farm Solution is combined directly to the apps. The data from the standalone app is transferred to and stored at a central server in a host e.g. in a dairy processing company. Before this system can be introduced in India, specific requirements have to be identified and implemented.

In 2016, an orientating market research was carried out for Uniform-Agri in India by Ashwin Ladhe. From that research it was cleared that there is opportunity for Uniform-Agri software in India as most of the cooperatives are interested in keeping track of the management carried out by the farmers to increase the milk yield per cow along milk quality. The information lacking was which milk factories or cooperatives will/can be the clients of Uniform-Agri in India.



In 2017, Vijaya Pagare developed a plan for introducing the app based system to dairy processors potentially interested in the product. For her research she did interviews with decision makers in Indian dairy processors or related industries in March and April 2017. In the interviews the product as it can be expected in the market in India was demonstrated so proper feedback was obtained. From that research the following results were obtained:

a) Evaluation of the benefits of the app system for farmers and dairies:

At the moment about 20% of production is ending up in the formal market organised by cooperatives, government or private sector. This amount can increase if local processors can help farmers creating better profit in collaboration with chain partners. It depends on the position of the individual processor and the network of connected farmers if there is enough potential for growth of milk production and willingness to innovate and invest time, effort and money in creating benefits out of a data collection system. Some dairy processors interviewed showed enough evidence of their innovativeness that the system has a fair chance of success.

b) Reaction of the local farmers and intermediate on app system:

During the field research, the app system was introduced to local farmers and processors. Most of them are interested in the features it offers, but concerned about the price of the software. There is quite a difference between companies to what extend they are willing to communicate about what they require.

c) The key condition to introduce the app system in India is the local language in the software. Service-/helpdesk should be available in India. Software trainings for farms should be arranged, so the farmers should be enough literate to understand the training.

d) The next important step is to motivate the farmers and milk processors and cooperatives to purchase the app system and create the awareness of the benefits in dairy farming. For this purpose trainings should be provided on farm management to the farmers.

Impact and investments of improved record keeping handling

Having better cows means having cows that are more efficient in milk production, fertile, healthy, strong, profitable and sustainable. This expected economic benefit can be expressed as a higher amount of milk per day per cow throughout the whole year or lifespan of a cow, with milk quality levels as to be expected for the specific breed. Comparing the potential of breeds showed that an increase of at least 10 kg milk per cow per day is possible. However, breeding potential will only be expressed in optimal circumstances. Taking into account that every breed has other requirements for the environment it is clear that financial benefits of having a good breed cannot be taken for granted. Getting better cows through breeding means better selection of genetics that perform best in local circumstances. Selection starts with setting up a shared cow based measurement and a data recording system. On top of this, with the help of processed information analysed by a data collecting organisation, dairy farmers will also come to know which dairy cow is performing according to the standard.

Based on the report, dairy farmers can take important decisions based on financial calculations and improve their farm management. A long term benefit for the medium sized dairy farmers is that the farm will have a better profitability, which will increase the investment potential.



In this FDT project the FDBA system and the Uniform Agri App systems were investigated and confronted with the dairy practices in Pune district. The FDBA system addresses the issue of accurate measurement and improvement of animal performance on individual farm level. In this way the farmer gets better awareness of the performance and breeding value of the animal. Health and performance problems can be identified better and farm management and milk production will increase. The Uniform Agri App system supports chain actors as dairy processors to stimulate farmers using data in their farm management. Farmers should do data recording themselves, setting targets and making action plans leading to a higher milk production, less fluctuations in supply and better quality of milk. A combination of both systems is likely to be a good way to motivate the directly involved parties: farmers, local processing industry and AI service organisations.

The costs of implementation of the system are hard to estimate, but will be roughly 10 to 15 euro per cow per year (750 to 1125 INR). This only applies when a large number of farms and cows are in the system, as a result making the role of the processor dominant for the introduction. When an increase in production of 6 litres per productive cow per day is reached (1800 litre per year), the marginal costs are between 0,5 and 1 INR per litre milk. Key success factors for both systems is the willingness of farmers, processors and stakeholders to share forces and invest in further development and introduction of a good system. Those stakeholders are the feed industry, technology and related service suppliers and (semi) governmental facilitators.



Box 3: Innovation in record keeping.

Revenue

Better management of dairy farms will lead to better breeding, better management, higher milk production, more animal welfare and better quality. An important condition for better management is having the right information and being able to work with it. In other words: 'better record keeping'. For better record keeping it is necessary to have a working (and simple) system, give input to this system (data input) and using the data or information that this system provides.

Costs & investment

For record keeping, a farmer has to invest in hardware (handheld) and software (app). The total investment needed is INR 77,000 (€ 1.000,-). Yearly expenses (software license) are INR 30,800 (€ 400,-)* per year.

Benefits & return on investment

With an investment of INR 77,000 (€ 1.000,-) a farmer can earn an additional INR 1,43,836 (€ 1.868,-) per year. The return on considering an Indian farmer with:

- 21 cows, each producing 12 liters milk and producing 300 days every year
- A milk price of INR 23 (€ 0,30)
- An expected increase in milk production 10%.

The additional revenue will be: $21 \times 12 \text{ L} \times 300 \times \text{INR } 23 \times 10\% = \text{INR } 1,73,880$ (€ 2.268,-) per year. The rate on investment is $> 100\%$.

Furthermore there are benefits to be obtained, as:

- An improvement in animal welfare (prevent or cure illness in a more early stage).
- Improvement in milk quality (being able to control and manage milk quality).

* Exchange rate 25 September 2017 € 1 = INR 77



3.4 Innovations in support of dairy farm management

Upgrading the present family dairy farming systems towards more efficient and more profitable farming systems requires many changes in farming activities and farm management. The main motivator for the labourers and the management is getting higher profits from farming through a higher production per cow and better quality of milk leading to a higher price. The related key success factor is managing the quality of resources: animals, housing, top soils, crops, machinery and human resources. Important side effects are improvement of efficiency and sustainability.

In Pune dairy family farming there are a limited number of labourers. Because of relative low labour prices it is expected that also when farms grow in size only a limited amount of mechanization and automation will be introduced. Implementation of human resource management practices including extensive staff training as implemented in successful larger scale dairy farms, could make the farm work more attractive and effective. In the context of Indian cultural tradition this is pretty much a challenge. Simply copying training practices from Germany, New Zealand or USA to India is deemed to fail. Development of farm specific standard operating procedures (SOPs) and staff training fitting in the local social, cultural and economic environment is required.

In the FDT project a supportive method for tailor made development of human resources has been developed and made practically applicable at the FDT farms by Naresh Kondala. The method is based on basic quality management principles that are highly relevant in this stage of development of this farming system. Through this method local trainers, advisors, supervisors and workers can jointly develop new farm specific standard operating and training programs. In the development process of the method, input was used of local farmers, Indian and Dutch students and specialists acquainted with the local farming situation. Chosen is to start from a total quality management perspective and using cause-effect diagrams for problem solving and avoiding potential problems. The method is presented in box 4.

The analysis has to focus on the animal production targets in relation to the needs of the animal. Key principle is that when having cows that are genetically capable to produce well, the level of production is limited by not taking enough care for the needs of the animal to express this genetic potential. The main animal production problems that were expressed by the farmers in the FDT project are: 'repeat breeding', 'lower milk production', and 'low milk quality'. The analysis could take these three main problems as a starting point.

Next is selecting manageable causes (factors) and formulating attainable targets related to these factors. It is very important that the factors can be related to specific tasks and activities, in which 'milking' can be considered as a task and 'checking udder for complete milking' as an activity. So for the problem of 'low milk production' the factor 'milking practices and equipment' within the cluster 'mastitis' can be selected to focus on. The activity related to this factor is 'checking udder for complete milking', meaning no large amount of milk must be left within the udder after milking. The measure in this case is to train the milker on applying this activity with correct checking standards and the right corrective actions. This can be formalised in a written SOP and a procedure to check that the worker is really applying the right practices.

Key element in this whole process is to keep it simple and to motivate the worker as well as the farm manager. Data recording has to play a crucial role in that. Because data



recording practices have to be achieved at a higher level than only farm level, it depends on what data locally will be acceptable to record how the motivation and control process will take place.

Box 4: Seven step model for making farm specific SOPs

1. Getting a clear picture of farm resources and practices, including farming objectives.
2. Deciding on main problems or risks in relation to farming objectives based on analysis of available information: 'Data' (written reports), 'Cows' (animal observations) and 'Farm' (interview and general observations).
3. Make a Cause Effect Diagram (CED) for each main problem/risk showing what are important factors (manageable causes) and clusters (of causes); motivated by theoretical backgrounds on relevant farming aspects; for selection of the causes take into account: chance of occurrence, impact, manageability by farm workers.
4. Make an indicator analysis, showing which farm specific indicators (including observations) helps monitoring the chosen factors, related to theoretical backgrounds.
5. Make a problem history analysis based on in depth analysis of indicators based on Data, Cow and Farm information; if not enough information is available collect yourself data creating a farming history.
6. Decide on practical measures that could be taken by the farmer; include analysis of expected impact of those in relation to the CED and related to the problem history analysis; include a cost-benefit analysis for the proposed measures including financial and non-financial aspects; including animal and land performance and sustainability.
7. Formulate Standard Operating Procedures (SOPs) related to the practical measures; connect those SOPs to monitoring tools and procedures for corrective actions when required.

Within the FDT project general cause effect diagrams are developed for the three main problems. Next to that it is described how to connect those potential causes with related observations, specific tasks and activities and with advisory tools. As an example the cause effect diagram for 'low milk production' is presented in figure 16. When applied in a training program a choice has to be made on what factor to focus. Meanwhile it is very relevant to show the whole cause-effect diagram, because it will stimulate the critical approach of the farmer.

In this discussion it is important to always take the needs of the animal and the required animal production targets as a starting point. That means that understanding of biological and economical principles of animal husbandry has to be discussed. Only in that case the workers and the managers are able to implement principles of self-control and take decisions that will lead to improved performance of the animal and the farm, having a higher milk production and better milk quality.

It is expected that advisory services of KVK or private companies are supporting farm managers in implementation of this method. Firstly advisors and innovative farmers have to

be trained to implement this system. International operating advisors from companies as Vetvice can play an important role in those training programs.

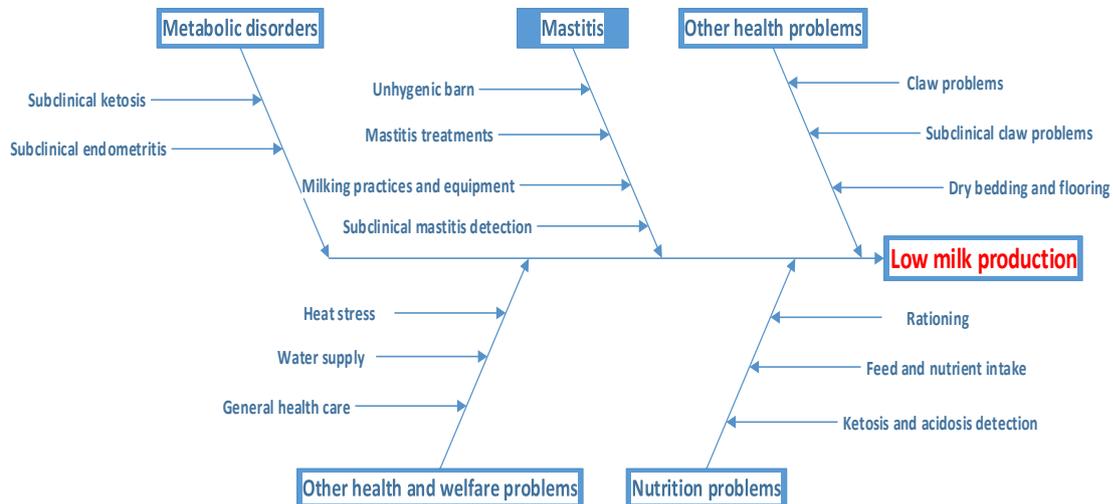


Figure 16: Cause effect diagram Low Milk Production.

3.5 Innovating value chains

Quality management at farm level

In the formal milk chain only a very limited number of quality aspects are monitored, the so called basic standards. Those only imply fat and SNF (Solids Non Fat) percentage, alcohol test and smell and colour. Some processors as Schreiber-Dynamix already apply a special standard to satisfy the needs of specific customers, for which they only use milk of larger farmers producing more than 500 litres per day.

In spring 2016, a general analysis was made by Vishvajeet Patil. In his study he found that there are lots of problematic stages where milk quality deteriorates such as:

- Traditional husbandry with hand milking and poor quality cluster machine milking;
- Unhygienic milking areas;
- Lack of cooling facilities for the milk;
- Lack of knowledge and awareness of milkers on milk quality;
- No recording and no management on any aspect relevant for milk quality, apart from Fat and SNF percentage.

Because in organized dairy farming integration of technology plays a crucial role in producing high quality of milk there is urgent need for technology. However the local situation needs to be considered to bring the desired result. Regarding milk quality on farm level four aspects need full attention:

- **Animal Healthcare:** There are no major problems with dangerous diseases, but improper animal health care affects the productivity and final quality of the milk. The help of tailored-made methods and techniques for taking care of animal health will improve the milk quality, starting with a lower somatic cell count, and increase productivity.



- **Milking:** The milking process is mostly carried out by simple technology which improves milk quality to some extent, but has a high risk of contamination due to milk coming in contact with air. With the use of airtight systems this risk can be minimized. If the milk does not come in contact with air, the produced quality of milk will improve and can be sold at higher prices.
- **Storage:** The most important technology which can play a vital role in improving milk quality is the use of small coolers at or near the farm at milking. In India, the milk is very often not properly stored at 4 degrees Celsius within the standard time of 45 minutes. Only then growth of nearly all microorganisms will stop. This means practically that the some kind of milk cooling equipment should be at the farm, because the milking itself will take most often at least 60 minutes.
- **Feeding:** Special attention should be paid to feeding by proper rationing according to the requirement of animals and by preventing harmful residues and metabolites from the feed or water entering the milk.

Next to these the following factors are influencing the farmer in improving practices:

- **Lack of knowledge and awareness:** Farmers have limited knowledge on the use of technology and the real benefits or the purpose of the technology. Due to increased use of smartphones and social media this is changing, however the majority of the farmers do not have access to reliable sources of information.
- **Government support:** Taking into account the current milk quality status, the Indian government is interested in supporting technology integration. By governmental act KVK's were established in each state of India to transfer technology into Indian farms.
- **Market demand for high-quality milk:** There is an increasing market for high-quality milk and farmers are aware of that. The increasing demand for high-quality milk will stimulate the farmers to make use of technology.

Farmers are ready to adopt Dutch technology but need knowledge, awareness and assurance of the market (i.e. the processor) for return on investment. The small herd size is another issue preventing the farmer to adopt the technology, and then farmers seek support from the government. If challenges are taken care of, then there is a lot of potential for GEA technologies to be implemented at Dairy farms in India. In collaboration with milk market players and governmental organisations it needs to run programs on creating awareness and access to knowledge with regards to presence and implementation of technology.

It is advisable that processors first set an upgraded set of standards for off-farm milk, connected to the international quality requirements for milk. Main components of those standards tests have to be: temperature of milk, colour, smell, purity, dirt, fat percentage, protein percentage, lactose percentage, bacterial count, somatic cell count, free fatty acids, detergent, freezing point, antibiotics.

Secondly, the processor has to set up a system for sample taking, giving feedback to the farmers and implement motivational measures for the farm management and farm workers to maintain the required quality level. That system has to be connected clearly to

the implemented physical process on how to bring the milk during or immediately after milking to a cooling facility.

Farming practices have to be improved so causes and risks for problems will be eradicated through appropriate standard operating procedures including clear corrective actions. Training of milkers is very important in that. It is advisable that farmers reward milkers in relation to training and performance.

In the development of standard operating procedures and farm workers training programs it is advisable to use the seven step model as discussed in paragraph 3.4. A possible cause-effect diagram, not yet simplified is presented in figure .

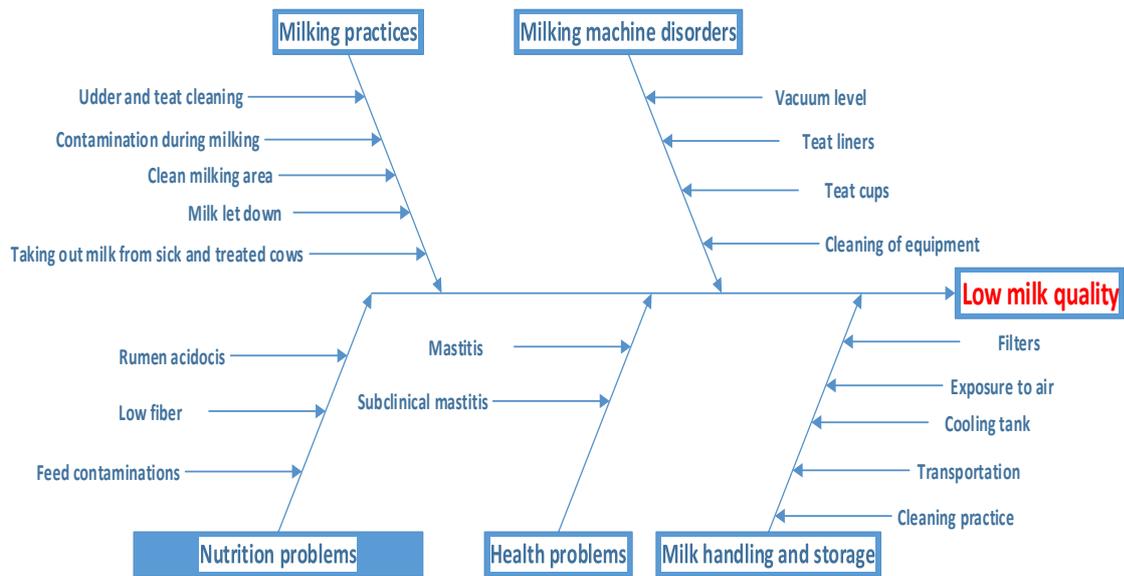


Figure 17: Possible cause-effect diagram Low milk quality.

Innovative value chain of untouched milk

Marri & Tingiira (2017) describe “untouched” milk as ‘a unique product **“from teat to glass”**, retaining the natural state, with high nutritional value in terms of fat, protein and calcium’, not-pasteurised and not-homogenised. Ramakrishna (2017, pers. comm), consultant to Yash Agro however describes untouched milk as breast feeding: **“from udder to mouth”**. Baramati Agro (and Yash Agro) are developing a milk product which finds its way to the final consumer with minimal touching by hand or contact with air and processing practises. In his thesis, Rajaram Ingale (2017) defines untouched milk as ‘milk without adulterations and with a good protein and fat content through milking with proper hygiene, avoiding manual touch and cooling at the farm level’. Due to the Food Safety and Standards Authority of India (FSSAI) quality standards, the milk has to be pasteurized, but not necessarily homogenized.

While Marri & Tingiira (2017) suggest for Yash Agro to integrate the production and processing in order to avoid any manual touching, Yash Agro proposes a “Village Milking and Cooling System” for smallholder farmers. Ingale (2017) proposes a chain with Bulk Milk Coolers (BMC) (see figure 18).

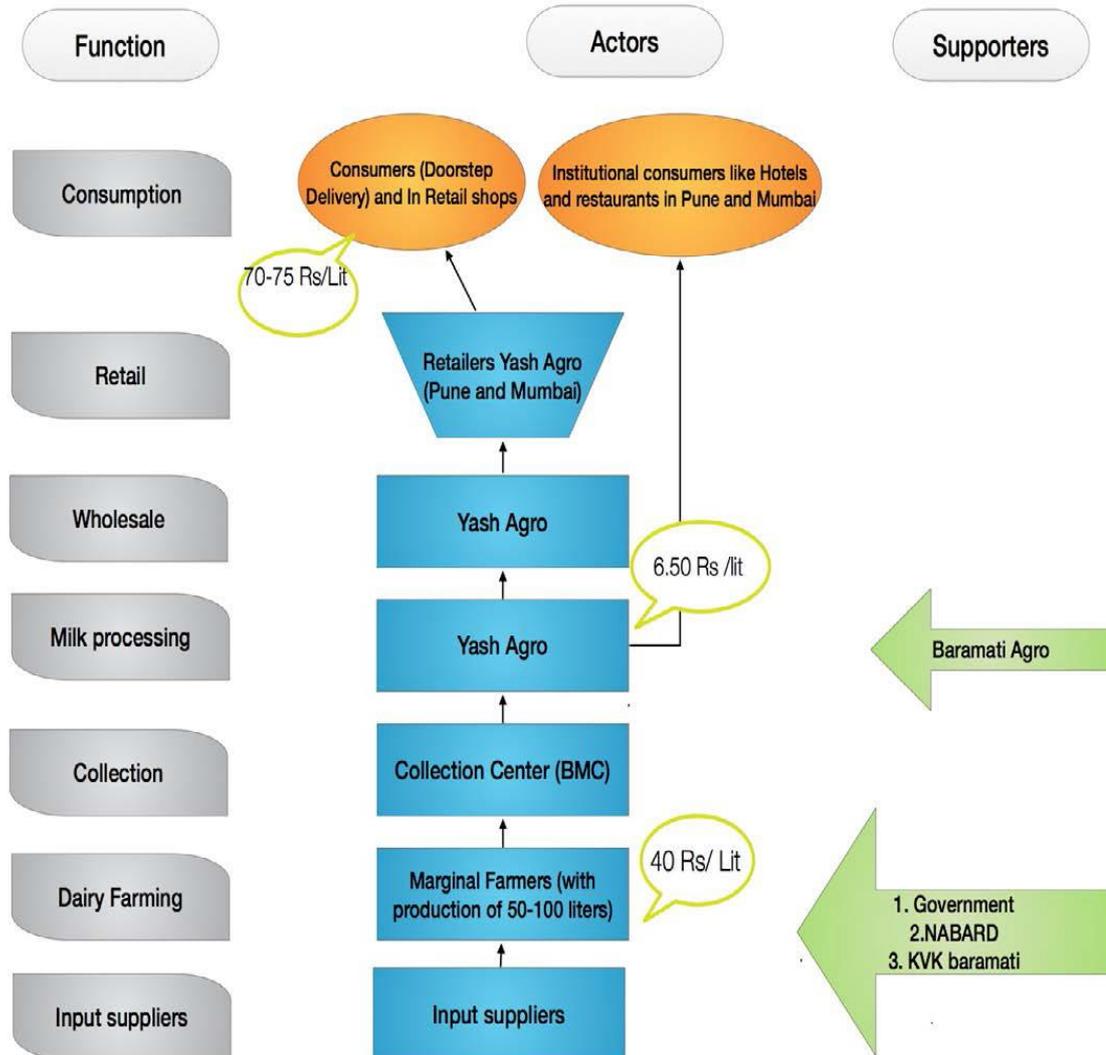


Figure 18: Proposed Untouched Milk Chain with BMC for Yash Agro.

In order to reduce the transportation of untouched raw (and unchilled) milk, the Bulk Milk Cooler of 500 kg milk serves 5 smallholder farmers, producing maximum 100 kg milk and living 5-10 km around the collection centre. Besides this, the smallholder farmers should install a (bucket) milking machine and a clean milking area. Yash Agro (pers. comm) could invest in those milking machines and lease them to the farmers. Different forms and feasibility of collective/community BMC's, community milking or mobile milking have to be investigated further.

Cost price Bulk Milk Cooler (BMC)

The investment of a milk bulking cooler will be done by Baramati Agro (Yash Agro). The investment costs for one BMC are 600.000 INR, while the operation costs are 17.000 INR/month (Ingale, 2017). If the capacity is 80% (400 L/day), the cost price of the BMC is almost 2 INR / L (see box 5).



Box 5: Cost price BMC.

Depreciation BMC $600.000 - 0 / 15 \text{ year} = 40.000 \text{ INR / year}$
Interest BMC $(600.000 - 0) / 2 * 10\% = 30.000 \text{ INR / year}$
Maintenance BMC $600.000 * 2\% = 12.000 \text{ INR / year}$
Total Investment costs = 82.000 INR / year
Total Operational costs = $12 * 17.000 = 204.000 \text{ INR / year}$
Total investment and operation cost = 286.000 INR / year.

Total Milk collection = $400 \text{ L} * 365 \text{ days} = 146.000 \text{ L / year}$

Cost price for a small BMC - milk collection is $286/146 = \text{almost } 2 \text{ INR / L milk.}$

Cost price of a double bucket milk machine (DBMM)

The investment costs for a double Bucket Milking Machine is 62000-68000 INR², including installation. The operational costs are max. 2300 INR per month. The cost price of the bucket milking machine is 0.125 INR/L (see box 6). For a single bucket milking machines are the investment costs 37000- 43000 INR³, including installation. The operational cost and the milk production are the same. The cost price will be 0.113 INR / L milk.

Box 6: Cost price of a double bucket milk machine.

Depreciation DBMM $65.000 - 0 / 15 \text{ year} = 4.333 \text{ INR / year}$
Interest DBMM $(65.000 - 0) / 2 * 10\% = 3.250 \text{ INR / year}$
Maintenance DBMM $65.000 * 2\% = 1.200 \text{ INR / year}$
Total Investment costs = 8.783 INR / year
Total Operational costs = $12 * 2.300 = 27.600 \text{ INR / year}$
Total investment and operation cost = 36.383 INR / year.

Total Milk production / farm = $80 \text{ L} * 365 \text{ days} = 292.000 \text{ L / year}$

Cost price for a DBMM is $36.4/292 = 0.125 \text{ INR / L milk.}$

² <http://www.dairyfarmsolutions.org/milking-machine.html#trolley-type-double-bucket-milking-machine>

³ <https://www.indiamart.com/proddetail/single-can-single-bucket-milking-machine-15787788362.html>



Box 7: Innovation in the dairy chain: A1

Revenue

In the normal Indian dairy chain, milk is gathered at the farm and transported to a milk collecting centre, the customer or a milk processor. If the sector would be able to improve this chain and cool the milk to 'fresh and full fatted milk', a farmer would be able to obtain a higher price for his milk. Instead of INR 23 (€ 0,30)* per litre, a price of INR 42 (€ 0,55) will be possible. Considering an Indian farmer with:

- 21 cows, each producing 12 liters milk and producing 300 days every year
- A current milk price of INR 23 (€ 0,30)
- An expected new milk price of INR 42 (€ 0,55)

The additional revenue will be: $21 \times 12 \text{ L} \times 300 \times (\text{INR } 42 - \text{INR } 23) = \text{INR } 14,36,400$ per year (€ 18.655,-).

Other benefits are:

- Better milk quality: having a closed system with quality control will improve the quality of milk.

Costs & investment

For this improvement investments are needed in the milk collection and distribution system. The general expectation (and assumption) is that the milk collection company will take care of these investments, so the investment for the farmer is nil.

If the farmer makes a choice to sell his milk directly to the consumer, he will have to invest in cooling equipment for approximately INR 1,92,500 (€ 2.500,-).

Benefits & return on investment

With no investments and no substantial additional costs, an extra benefit of INR 14,36,400 per year (€ 18.655,-) can be generated for the farmer if he delivers his milk to a factory. If a farmer sells his milk directly to the consumer an investment of INR 1,92,500 (€ 2.500,-) has to be made and the return on investment will be > 100%.

Furthermore there are benefits to be obtained, as:

- Improvement in milk quality (a closed chain with quality control).

* Exchange rate 25 September 2017 € 1 = INR 77

Innovative value chain of local milk

Patil (2017) describes the feasibility of the expansion of two local short fresh milk chains of A1 and A2 milk. Dairy farmers with exotic (HF) and desi (Gir) cattle respectively deliver directly to consumers after chilling and packaging the milk in plastic bags. In both cases, the milk is pasteurized nor homogenized, because the buyers, health-conscious consumers, require the freshness and the full fatness of the milk. Due to the direct delivering, the farmers are not investing in pasteurisation of the milk.

The Gir farmer, Sashikant Taware, projects a daily A2 milk sale of 1000 L, based on the current selling experiences in Baramati. Therefore, milk production must be partly outsourced. Nepal & Liban (2017) suggest to establish a production company of 10 farmers, each producing 100 L milk and commonly organising the processing and distribution of the milk as well as sharing the profits. Patil (2017) proposes however an A2 milk chain with a private company (Mr. Taware) arranging the collection, processing and distribution of the milk (see figure 19), offering the desi farmers a higher than regular off-farm milk price (55 INR/L) in order to make strong chain links.

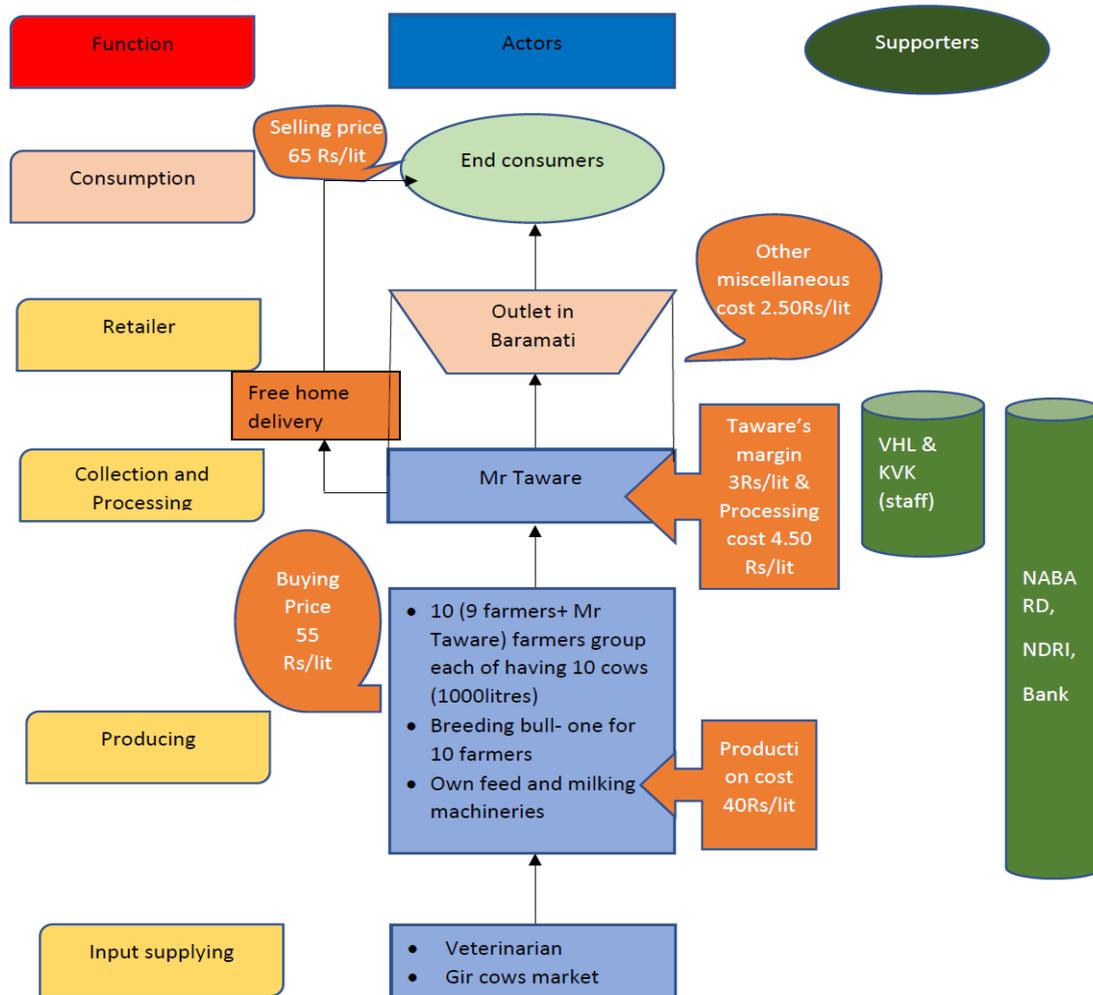


Figure 19: Possible Value Chain for A2 milk.



The value proposition of this A2 chain is “fresh, full fat A2 milk of desi cows”. The value share for farmers is 84%, while Mr. Taware’s company takes 16% of the value share (see figure. 20). The (profit) margin of the farmers is 23%, while the margin of Mr. Taware is 5% (see figure 21). For the given volumes in this chain design, it means that each farmer gets a daily margin of 1500 INR and Mr. Taware gets a daily margin of 3000 INR.

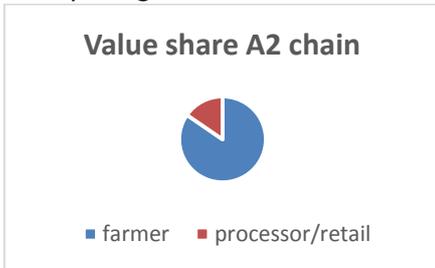


Figure 20: Value share in A2 chain.

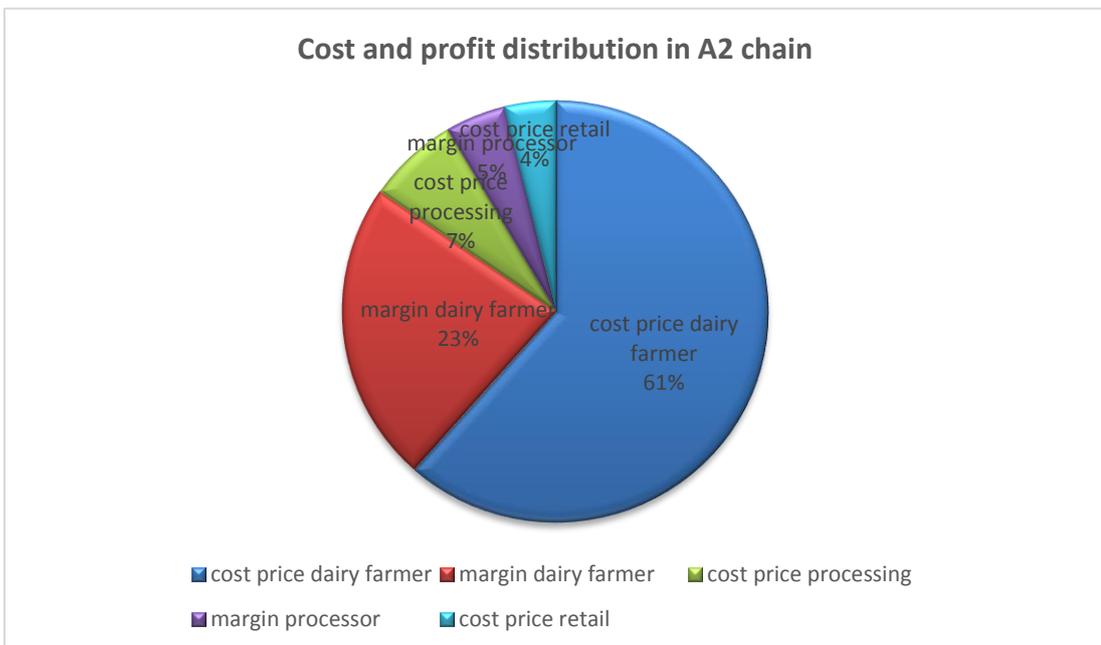


Figure 21: cost and profit distribution in the A2 chain.

The HF dairy farmer, Nilesh Jamdade, projects a daily A1 “untouched” milk sale increase from 75 to 200 L, based on the current home delivery selling experiences in Baramati. The value proposition of this A1 chain is “fresh, full fat cow, untouched milk of constant quality, delivered at home freely”. Therefore, he wants to invest in milk cooling, milk packaging installation and simple milk quality analyser, besides the investments in production increase. The production increase can be reached by raising the number of cows or the production per cow. Mr Jamdade can also partly outsource his production.

Patil (2017) proposes a new customer segment, such as restaurants and industry canteens (see figure 22), stating that he can sell “untouched” milk for 50 INR / L instead of 35-40 INR / L for the current “fresh” milk.

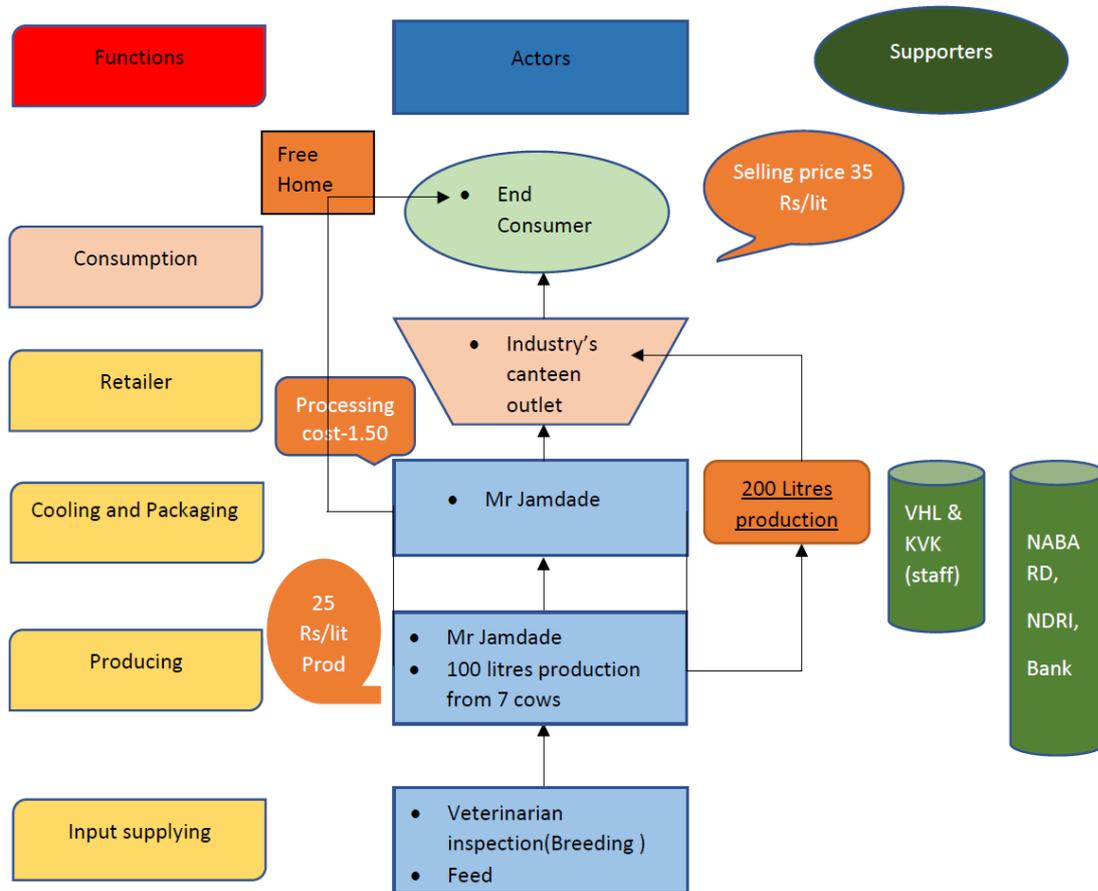


Figure 22: Proposed Value Chain for local A1 milk.

The investment costs for the additional equipment (occasional) are around 82.000 INR (Bulk Milk Cooler of 200 L = 30-40.000 INR; automatic packaging machine 20-30.000 INR; milk analyser 10-12,000 INR). Operational costs are assumed* on 10.000 INR / month. The cost price for the milk processing equipment is assumed*⁴ on 2 INR / L (see box 8).

Box 8: cost price milk processing equipment

Depreciation $82.000 - 0 / 10 \text{ year} =$	8.200 INR / year
Interest $(82.000 - 0) / 2 * 10\% =$	4.100 INR / year
Maintenance $82.000 * 2\% =$	1.640 INR / year
Total Investment costs =	13.940 INR / year
Total Operational costs = $12 * 10.000 =$	120.000 INR / year
Total investment and operation cost =	133.940 INR / year.

Total projected Milk production = $200 \text{ L} * 365 \text{ days} = 73.000 \text{ L} / \text{year}$
 Cost price for milk equipment is $134 / 73 = 1,84 \text{ INR} / \text{L milk}$.

⁴ *Assumptions are checked with Mr. Bhosale (Yash Agro).



Box 9: Innovation in the dairy chain: A2.

Revenue

In the normal Indian dairy chain, milk is gathered at the farm and distributed to a milk collecting company, the customer or a milk factory. If a farmer would shift from A1 to A2 milk (a more healthy kind of milk) and deliver fresh milk directly to consumers, his milk price could grow from INR 23 (€ 0,30)* to INR 54 (€ 0,70). To be able to make this change, he would have to use only indigenous breeds with a lower milk production (7 litres instead of 12 litres per day) and invest in cooling and packaging equipment. In this case, the starting point is very important. Does the herd consist of indigenous breed or crossbred. Considering an Indian farmer with 21 indigenous cows:

- each producing 7 liters milk and producing 300 days every year;
- A current milk price of INR 23 (€ 0,30);
- An expected new milk price of INR 54 (€ 0,70) for the A2 milk.

The additional revenue will be: $21 \times 7 \times 300 \times (\text{INR } 54 - \text{INR } 23) = \text{INR } 13,67,100$ (€ 17.755,-) per year.

Secondly, considering an Indian farmer with 21 cross bred (HF) cows:

- each producing 12 liters milk and producing 300 days every year;
- A current milk price of INR 23 (€ 0,30), before changing the herd;
- An expected new milk price of INR 54 (€ 0,70) for the A2 milk, after changing to indigenous.

The 'new' revenue will be: $21 \times 7 \times 300 \times \text{INR } 54 = \text{INR } 23,81,400$ (€ 30.927,-) per year.

The 'former' revenue was: $21 \times 12 \times 300 \times \text{INR } 23 = \text{INR } 17,38,800$ (€ 22.582,-) per year.

So, the additional revenue would be INR 6,42,600 (€ 8.345,-)

Other benefits are:

- Better milk quality: A2 is supposed to be more healthy than A1 milk.

Costs & investment

If a farmer has to change from crossbreeds to indigenous breeds, he would sell his current livestock and buy a new. In terms of investment we can consider this as no additional investment. If a farmer changed from crossbreeds (HF) to indigenous milk production will decline to 2/3 of the original volume. A result of this a decline in variable costs. In this case there is a cost reduction of 21 cows \times 5L \times 300 \times INR 13 (€ 0,17) per litre = INR 4,09,500 (€ 5.318) per year. In both cases there is an investment to be made in cooling equipment and a selling point of INR 2,31,000 (€ 3.000,-).

Benefit & return on investment

With an investment of INR 2,31,000 (€ 3.000,-) a farmer can generate an additional benefit of INR 10,52,100 (€ 13.664,-) (if changing from HF to indigenous) or INR 13,67,100 (€ 17.755,-) (changing from A1 to A2 milk with an existing indigenous herd). So the return on investment will be > 100%.

Furthermore there are benefits to be obtained, as improvement in milk quality (A2 is healthy) and creating a new market. A disadvantage, in terms of feeding India, is a lower milk production.

* Exchange rate 25 September 2017 € 1 = INR 77



3.6 Towards a new farm model

In this section the development of innovative farming models as potential future farming systems is discussed. The discussion is based on the present farming system as described in section 2.3, and the innovations discussed in previous sections of chapter 3. So here we focus only on those family farms in Pune district that now have between 20 and 100 dairy cows including young stock and dry cows and that want to improve the profitability with new technology. From farming perspective there are many types of farms to be distinguished in this group. The development of the farm organisation depends very much on how the farmer organises his sales and related business contacts and financial arrangements.

Traditionally the business model of Indian family dairy farms focusses on cash generation. Dairy animals provide the family with a constant stream of cash because the milk is sold throughout the year. This system is limited in its capacities of creating reservations for future investments and it offers very little security for lenders. Banks most often only grant loans with irrigated land as collateral.

Becoming a profit based company requires application of micro economic principles to farming practice in each aspect of decision making in the farm, starting with financial planning. Regarding this FDT study this means it is important for the farmer to find out what is the expected increase of revenues and costs linked to the innovations connected to Dutch products and services.

The main factor determining the pathway for farm model development will be the sales organisation and to what extent the farmer is successful. Organising your own sales, maybe with a group of farmers is one option in that. The other possible successful option is having stronger collaboration with a cooperative or private processor.

The second factor is the production organisation. From this point of view the main difference will be the choice for the type of breed of cow and the production organisation and management skills of the farmer. Depending on the type of animal the production level will be different and the production system will be different because of different feed and climatic requirements. Concerning production organisation and management it is important that the skills of the farmer increase together with an improved support or advisory system, in order to make good choices fitting individual circumstances.

In this section the possible development of two types of farms is compared, combining a different sales organisation and production organisation. Some indicative calculations are made, not pretending any conclusions on what is a good or bad development. It will only serve as a model that could be helpful for farmers and advisors in making specific plans. The figures are chosen based on the total collection. The two types of farms are:

- 'A2 farm', that farm is selling milk of indigenous breeds directly to consumers
- 'Contract farm', that farm is selling milk of cross breed HF cows according to certified industrial quality standards and is supported in investment and several services by the processor

From these two types of farms the business case will be described in relation to the innovations presented in housing, nutrition, breeding and record keeping and farm management regarding production and milk quality. The main questions is how the



innovations and the development of the farm will increase profitability and other (shared) values.

It is important to realise that the outcome of farmers' decision making is not only depending on the question if they can make a profit or not. Still the impact on availability of cash is an important aspect in Indian life, but also other values are important: improving the dairy product market position, increase in future value of farming assets, impact on biodiversity and natural environment, labour circumstances, qualification of labourers, legal and political position, specific cultural and religious aspects and social impact for the labourers and farm owner. Especially when these values are shared values within the production chain and linked to local stakeholders, profit based investment capacities can be realised much easier.

Impact of innovations on the business models

To make a clear comparison and study the effect of the innovations on economic result the size of both farms is kept the same, they have the same amount of animals and land available. Because the A2 farm is milking indigenous breeds the milk production per cow will be lower but the milk price will be higher. In this thought experiment the innovations will be the same at both farms but the production outcome will be different. The setup of these farms as well as the main impact of the innovations on the productivity is listed in table 8. The consequences for the profitability of the farm is listed in table 9. In the calculation all figures are presented in INR (Rupees), the exchange rate as per Sept. 6 2017 is 76 INR per 1 Euro.

The basic farming system is having 20 cows for both farms, including dry cows. The A2 farm has an average daily sales of 110 litres for 50 INR per litre and the regular farmer of 170 litres for 28 INR per litre. They have both a simple free range stable as described in section 2.3 and have feed cost of 8 INR per litre milk. It is estimated that the farm profit before paying labour costs and tax are for the A2 farm 13,40,000 INR and for the Contract farm 8,60,000 INR.

The first step of improvement to be done is to apply data recording and improve farm management based on data. Also the feeding has to be improved and additional silage will be sold. Basic measures in barn design are taken as described in section 3.1 (design 1.0) to reduce the heat stress.

It is expected that the average milk production of the cows in the A2 farm increases from 6.7 litres per cow per day with 25% up to 8.3 litres per day. The total daily milk production will be then 140 litres. The HF crossbreds in the Contract farm is expected to have a 50% increase in milk production, from 10 to 15 litres per day. The total production on that farm will be then 250 litres per day.

Due to the changes it is expected that feed costs increase, the extra milk will be produced for 10 INR feed costs per litre, in both farms. It is expected that breeding and data recording costs will increase with 1000 INR per cow per year. The yearly housing costs might also increase, assumed is with 20.000 INR. This could be because of a renovation and investment in smaller supplies and materials of 150.000 INR (approx. 2.000 EUR). In both farms the same cost level is taken into account, assuming there will be no big difference between the two farms on what they should do to meet a higher level of standards in animal production. The increase in the profit, without taking extra labour costs or tax into account is estimated at 3,60,000 INR for the A2 farm and 5,00,000 INR for the Contract farm.

**Table 8:**

Farm setup and impact of innovations.

	A2 farm	Contract farm
Present situation		
Number of cows	20	20
Average litre milk per productive cow per day	6,7	10
Litre milk per cow per year (300 productive days per year)	2000	3000
Annual farm milk production (litres)	40,000	60,000
Average daily milk production (litres)	110	170
First improvements in present barn and management, design 1.0 implemented		
Number of cows	20	20
Average litre milk per productive cow per day	+25% = 8,3	+ 50% = 15
Litre milk per cow per year	2500	4500
Annual farm milk production (litres)	50.000	90.000
Average daily milk production (litres)	140	250
New barn design 2.0 implemented		
Number of cows	30	30
Average litre milk per productive cow per day	+50% = 10,0	+ 100% = 20
Litre milk per cow per year	3000	6000
Annual milk production (litres)	90.000	180.000
Average daily milk production (litres)	250	500
New barn design 3.0 implemented		
Number of cows	30	30
Average litre milk per productive cow per day	+63% = 10,9	+ 125% = 22,5
Litre milk per cow per year	3250	6800
Annual farm milk production (litres)	97.500	205.000
Daily milk production (litres)	265	560

The second step of improvement is to further learn how to work with farm data in farm management including improved breeding. Also further gradual improvement in the barn, including application of better roofing material (design 2.0, details see section 3.1). The barn will also be extended as to have 10 cows more; 30 in total of which 25 are producing.

It is expected that the average milk production of the cows in the A2 farm increases another 25% up to 10 litres per cow per day. The total daily milk production will be then 250 litres. The crossbreds in the Contract farm are expected to have another 50% increase in milk production, from 15 to 20 litres per day. The total production on that farm will then be 500 litres per day.

Due to the changes it is expected that feed costs increase. The extra milk will be produced for 10 INR feed costs per litre, in both farms. Data recording, breeding and health care costs will increase because the herd size is increasing.

**Table 9:**

Consequences of innovations on financial results (all financial values in INR).

	A2 farm	Contract farm
Present situation		
Milk revenues	50*40,000=20,00,000	28*60,000=16,80,000
Milk price per litre	50 INR	28 INR
Feeding costs	8*40,000=3,20,000	8*60,000=4,80,000
Health, breeding and data recording costs	20*15,000=3,00,000	20*15,000=3,00,000
Housing and machinery costs	20,000	20,000
Other costs not including labour	20,000	20,000
Profit	13,40,000	8,60,000
First improvements in present barn and management, design 1.0 implemented		
Additional milk revenues	50*10,000=5,00,000	28*30,000=8,40,000
Milk price per litre	50 INR	28 INR
Additional feeding costs	10*10,000=1,00,000	10*30,000=3,00,000
Additional breeding and data recording costs	20*1,000=20,000	20*1,000=20,000
Additional housing and machinery costs	20,000	20,000
Additional profit	3,60,000	5,00,000
New barn design 2.0 implemented		
Additional milk revenues	50*40,000=20,00,000	28*90,000=25,20,000
Milk price per litre	50 INR	28 INR
Additional feeding costs	10*40,000=4,00,000	10*90,000=9,00,000
Additional breeding and data recording costs	10*16,000=1,60,000	10*16,000=1,60,000
Additional housing and machinery costs	2,00,000	2,00,000
Additional profit	12,40,000	12,60,000
New barn design 3.0 implemented		
Additional milk revenues	50*7,500=3,75,000	28*25,000=7,00,000
Milk price per litre	50 INR	28 INR
Additional feeding costs	10*7,500=60,000	10*25,000=2,00,000
Additional breeding and data recording costs	0	0
Additional housing and machinery costs	5,00,000	5,00,000
Additional profit	- 1.85.000	0

The yearly housing costs might also increase, assumed is with 2.00.000 INR yearly; including costs for milking equipment and cooling. The investment to do this is roughly estimated on 20.00.000 INR (approx. 25.000 EUR). A loan is needed to do that investment. Again in both farms the same cost level on housing has been taken into account. The increase in the profit, without taking extra labour costs or tax into account is estimated at 12,40,000 INR for the A2 farm and 12,60,000 INR for the Contract farm. This is the extra profit without



taking a possible higher milk price into account because of better milking and cooling equipment.

The third step of improvement is to build a complete new barn according to design 3.0 (details see section 3.1). Maybe another step in increasing the milk production might be taken. It depends very much on the difference in costs between the design 2.0 and 3.0 and the expected increase in milk production if it will be profitable. In this case the investment is assumed to be 50.00.000 INR (approx. 65.000 EUR) higher because of larger scale reconstruction required. For the regular farm another increase in yearly housing costs of 5.00.000 INR is the result. This means an increase of daily milk production with at least 60 litres with 30 cows is required. For the A2 farm an increase of 35 litres daily is required.

Development scenarios, conclusions and recommendations

In order to develop farms described in the previous paragraph farmers could have to act in collaboration with key partners. The main elements of that action plan are described in table 10. The proposed entrepreneurial activities of the farmer are ordered by using the building blocks for making a business plan according to the business model canvas method.

As shown in table 10, it is clear that feed providers, technology providers and processing companies are the key industry partners for family farm development. Service and research providers that are private, NGO's, KVK's and governmental organisations as NBBB, can stimulate jointly the acceptance of products and services through demonstration projects and loan support or lease support programs for any kind of supportive investments. Linking those service providers with the key industry partners is very important.

Demonstration projects have to show that innovations can be implemented at farm level in a practical way. Dutch companies can be involved through local business partners in those demonstration projects.

**Table 10:**

Key farm development activities.

	A2 farm	Contract farm
Value Proposition	Setting and implementing farm specific standards on product and quality	Accepting and implementing standards on product and quality set by the processor
Customer Relationship and customer segments	Improving sales and marketing tools	Negotiating a contract with the processor
Channels	Implementing processes and procedures securing customer satisfaction and involvement	Setting up communication with processor about milk sales and specific supportive services
Key Partners	Set up own network securing feed supply, organising health care, breeding and management support	Getting acquainted to and implementing processors network securing feed supply, organising health care, breeding and management support
Key Resources	Investing in new barn design fitting local requirement, but optimizing costs, animal welfare, management of animal care and feeding; having a milking parlour, own cooling tank and milk processing unit.	Investing in new barn design fitting local requirement, but optimizing costs, animal welfare, management of animal care and feeding; having low technology but effective milking system.
Key Activities	Start data recording on milk production per cow and other data of relevant aspects of animal husbandry and land use. Developing and executing farm specific farm workers protocols, train farm workers, focusing on improvement of animals, labour quality, barn and feed.	
Cost Structure	Using cost- benefit estimations for decision making, applying data recording on costs, reviewing decisions taken and development of risk awareness.	
Revenue Stream	Implementing basic data recording on revenues and quality aspects. Comparing different development options.	



4 Dutch knowledge and technology for the Indian dairy sector

4.1 Dutch knowledge and technology

This chapter gives an outline of existing products and services of the Dutch companies participating in the RAAK project, that we rated as ‘affordable and robust’ for Indian family farmers. It is based on a thesis research of Shahu Pratap Dhorde. The thesis itself provides a more complete overview of the research and reviewed technologies.

The products and services were assessed and rated by five criteria of frugal innovation, based on interviews, product information and field research at small scale dairy farmers in the Netherlands and India. The products we ranked with the help of multi-criteria analysis. Criteria for frugal technologies are:

1. **Simplicity:** the technology is simple or easy to understand and learn and accessible for the farmer. They have few features and functional requirements. The local accessibility of the service for the product is part of simplicity.
2. **Affordability:** the product can be purchased by very low income community. Which means low input and operational costs.
3. **Sustainability:** the technology contributes to social, environmental, economic and biological values, gives safety and does not deplete scarce resources in ecosystems.
4. **Good enough quality:** determined by the degree of excellence and functions.
5. **Ruggedization or longevity:** technologies made up of material that can resist an aggressive physical environment and last for a long period.

Products for record keeping and breeding

1. *Herd Management*

For record keeping, cows should have unique numbers. These can be numbered ear tags or collar numbers. Collar numbers are tags worn on the neck, attached to nylon or leather collars or straps, having certain numbers on it to record the cows. This facilitates record keeping on paper or recording cow information on smartphone apps. Costs of ear tags and neck straps combined with plates or collar numbers are about 4 euro’s (about 300 INR) per cow. These products can be obtained in India or by Internet.

Nedap offers a more sophisticated, ‘smart’ tagging system based on RFID (wireless radio frequency identification) under the name Nedap Cow Control that provides and stores information on location, heat detection and health of the cow. These systems are only recommended for larger farmers (>100 cows) as the costs for 120 cows are about 13.000 Euro (970.000 INR). Based on annual earnings (cow health, reducing calving interval etc.), the return on investment time under Dutch conditions is estimated to 2.6 years. However this technology cannot be rated as ‘frugal’, as it is too expensive for family farmers and services are not yet available in Baramati/Maharashtra. However, when developing new milking parlour systems these technologies might be integrated, combined with the introduction of data recording systems.



2. *Accurate heat detection by animal markers*

This product is extremely cost effective. Painting the tails of cows gives a visual indication of when a cow has stood to be mounted and consequently rubbed, showing that she is in heat. GEA has a brand of FIL tail paint, specifically designed for dairy cow heat detection. But of course also other (chalk based) products obtained locally can be used. It is easy to use and very cost-effective. For applying the product effectively, the farmer needs to have the knowledge when a cow will be in heat and he can apply the marker. The knowledge can be based on observations or records.

3. *Knowledge for breeding strategies*

Farmers can opt for two different strategies; breeding by using their own indigenous bulls or by artificial insemination. Knowledge on using indigenous bulls breeding systems such as record keeping and developing a breeding strategy in small populations is provided by Wytze Nauta Consultancy. If a farmer wants to breed with his own (indigenous) bulls, the number of bulls needed is related to the population of cows. There will be no semen cost for the cow and the farmer can lease the bull to another farm for breeding. Fees for consultancy activities by Wytze Nauta are too high for individual farmers and only can take place when subsidized.

CRV is selling semen and has a long experience with the Indian Gir in Brazil. In India, they are also focusing on the Gir and crossbreeds (75% HF and 25% Gir). At the moment, farmers in Pune are using their semen for 40 INR (0.523 Euro), which is affordable for them. However, the quality and origin varies or is unknown.

A problem for farmers is that they do not keep record of the daughter cow and pedigree, which makes it impossible to assess the breeding values of the cows and bulls. Developing an adequate record keeping system was part of this RAAK project. Record keeping supported by mobile app was developed by Uniform-Agri (see chapter 3.3 on innovations in record keeping).

Products for improving feed and silage

4. *Cow nutrition and Good health- nutrition supplements*

Animal nutrition supplements are mostly very cost effective and affordable. Products are not applied daily, but only applied when necessary by the farmer's or para-veterinarian's judgement. Many different supplements exist. Agriprom and other companies supply for example: ARCC250 to improve the liver efficiency and to make and/or keeps the liver fat free, Optistar yeast supplement that feeds proteins, CalciMag gel with minerals, Ketovit supplies vitamins, minerals, energy and Bovikal calcium. Animal nutrition and feed supplement products are easy to apply. Farmers need to know how much to apply in the feed. Instruction to use is often given on the packaging and by veterinarians. A point of attention is that most products need cooled storage.

5. *Metabolic functioning*

Products that support metabolic activities and proper feed intake, digestion, health and general energy and performance of the cow. Agriprom brings various products on the market for cows and calves, like Digestar- Digestar start-up, Digestar ZINK, Digestar Dairy gel, Digestar Pellet, Digestar Liquid Dispersible, Digestar Probiotic pack, Digestar Ruminant Gel.



The products are of low cost. The application of the products depend from the individual situation and condition of the cow.

6. Feeding -Quality of silage-

Agriprom and other companies provide additives which can be mixed through the silage. That produces enzymes that support the digestion of fibres and improves stability and bunk life by the production of fatty acids that inhibit yeast and aerobic bacterial populations. The products are known as silage inoculants and additives like Utrabond and Feed'More'.

Products for improving barn design and management

7. Cow drinking and watering

Watering and drinking troughs made of stainless steel material are produced by GEA. They cannot be corroded even considering the quality of water, and can live longer up to 10-20 years. They also can be manufactured locally.

8. Fly Control

Fly Control -Carlmarks Startset- this is a non-poisonous and environmental friendly sticky tape (flycatcher) that is very affordable for using in the milking barns and costs about 40 Euro's (3000 INR) for 400 metres. It is a cost effective solution to keep the number of flies low.

9. Curtains for barn and milking parlour.

Curtains for barns and milking parlours to protect the cows from climate (heath, cold and rain) are in high quality made of vinyl and a.o. provided by GEA. They can be used for every farm size, also to separate the stall and the milking parlour. Because of cost effectiveness, manually pulled curtains are preferred above electrically pulled curtains.

10. Calf Care -Young stock housing-

Agriprom is a vendor of young stock housing, such as Calf-tel DeLuxe, Calf-tel Pensystem and Calf-tel multimax. Baramati's farmers leave the young stock out in an open environment in a loose housing system, without any protection from climatic conditions. This leads to unhealthy growth of calves. The calf hutches offer an effective covering from climatic uncertainties, with a feeding trough and watering trough that can be cleaned easily. The calf hutches is affordable and effective, the price ranges from 316-499 euro and will last for 25 years. Calves should not be exposed to temperatures above 30 °C. To prevent heath stress, situate calf hutches in shaded areas. If you do not have naturally shaded areas, consider building temporary shade structures (like those used to protect ginseng crops from the sun) to keep the hutches cool. Feed and water should also be kept in the shade. These should be at least 14 feet (4.26 m) high to ensure good airflow.

11. Climate regulation

The most affordable and robust ventilation for farmers is ridge ventilation, by creating an open topping of the roof, covered by a cap. Other approaches to prevent overheating and



stimulate ventilation by innovative constructions or technology are discussed in chapter 3.1: Innovations in Barn design.

12. Camera's

Digital (wireless) barn cameras make it easier for workers and owners to monitor the cows by live footage of the cows and what is happening in the barn. The cameras cost around 150 Euro (11.000 INR) or more. The cameras are designed in such a way that they cannot be damaged or break even under the toughest conditions considering, wind, pressure, rain, high temperature, etc.

13. Barn Hygiene

A hygienic, dry and clean bedding for cows is important for healthy and clean cows. Baramati farmers that pay attention to this, add sugarcane thrash on the floor as a bed for the cows. In the Netherlands, products like Zorbisan Plus (GEA) are spread on the bedding to get a clean and dry bedding with less bacteria and flies.

Other means are available for stable hygiene, like Staldren and Brize hygiene powder (Agriprom) which can be spread in the barn. These granules and powders are not poisonous, bind ammonia and prevent flies and microorganisms.

The company Agriprom developed a Disinfection mat (hygiene mat) as an alternative to the traditional foot baths used to treat and prevent hoof problems. Hoof problems are one of the most important cost factors on the dairy farm and a priority culling factor. The claw mat is used to prevent infections and contamination and in case of problems. High temperatures in Pune may have effect on the lifespan of the mats.

14. Animal hygiene

For udder hygiene, Agriprom offers hygiene products: Oxyshield, a post-milking bi-component filmogenic teat dip product conditioner and cleansers. It protects the teat skin after milking by forming a moisturizing and very hygienic film. Other product for udder hygiene after and before milking: Deramsept and Cowipes (cleansing, sanitizing disinfecting wipes that help control mastitis)

All these products can be considered as 'frugal', they are available, affordable and simply applicable. They prevent the growing of bacteria and various harmful microorganisms, prevent mastitis, contribute to less micro-organisms in the milk and promote general udder health.

Products for improving milk quality

15. Milk tests

Different rapid do it yourself milk tests are available, that provide knowledge to the farmer of the quality of the milk to support quality management. Agriprom provides various quick tests, like Milk test Duplex BL and TET to test on antibiotics content, PortaSCC for cell count, their prices are in the range between 30 to 610 Euros (2300-4600 INR) for a set of 10 to 40 tests.



Further development of frugal technologies for the Indian Dairy sector.

The companies that participated in the RAAK Family Dairy Tech project offer opportunities for further research and development of frugal technologies. Such innovations are tailor made and should be initiated by the users, which can be a farmer, a group of farmers, processor, or any other organization active in the Indian dairy sector. To facilitate this, an overview of the company profiles is provided below.

GEA Farm Technologies: GEA Farm Technologies offers a total solution to the dairy farms. They offer everything from milk collection and the milk storage, automatic feeding systems, manure management, barn equipment, young stock solutions and services. Together with farmers they can design complete barns from smaller to large scale production units. They also are active in the field of milking parlours, cooling and dairy processing technology. GEA has a branch in India. (<http://www.gea.com/en/>)

Vetvice: Vetvice gives practical and consistent information on cattle housing, barn design and animal husbandry handling to farmers worldwide. They also deliver their knowledge to the advisors and suppliers in the world. They train and advice dairy farmers and farm workers. They also support advisors for further development of their products and services. (<http://www.vetvice.com/>)

Cowsignals: Training in dairy cow management is provided by Cowsignals. (<https://www.cowsignals.com/>)

WN Advies (Wytze Nauta): This is a one man company. Wytze Nauta is affiliated to the Dutch Bio-Organic cattle improvement association. Wytze Nauta supports the breeding activities for the dairy farmers. The cattle improvement association is setting up a dairy cattle breeding system for the organic dairy farmers in Netherlands, a.o. with traditional, indigenous breeds. (<http://www.wnadvies.nl/> and <http://www.biologischefokkerij.nl/>)

Agriprom: Agriprom Company is specialized in the dairy farming sector. This company provides solutions for the cattle housing equipment, like rubber mats cow mattresses, cubicles, headlocks, camera's and service products. They also sell products for the dairy farming sector. Their aim is to offer solutions for the total cow comfort. (<http://www.agriprom.nl/en/>)

Uniform-Agri : Uniform Agri develops, sells and supports dairy farm management software for dairy farmers all over the world. They are specialized for recording and managing farm data. They have a relationship with the leading milk parlour manufacturers, UK Milk recording companies and other industry partners to create solutions with their software. (<https://www.uniform-agri.com/en>)

CRV: This company is the Dutch cattle breeding organization. It is one of the leading herd improvement companies in the world. Their main activities are in the field of breeding cattle, collection and processing of cattle data, herd book activities, on farm services, etc. They sell semen of the bull worldwide. (<https://www.crv4all-international.com/>)

Vision4Energy: Vision4Energy is a specialist in heat exchangers. At present they sell heat exchangers in the horticultural sector, schools, offices, sports, industrial halls, residential buildings and also to dairy farmers. (<https://www.vision4energy.com/>)

Dutch Rainmaker: Dutch rainmaker is a young company involved in the activities of producing fresh water out of air or out of silty water. Their product application is based on two systems; 1. Air to water, 2. Water to water. They developed a windmill that is directly connected to a heat pump or cooling compressor to produce heat and cold. The air is cooled



and out of the water vapour in the air it produces about 7500 litres of water per day (this is air to water system). From existing saline water sources, up to 100.000 thousand litres of sweet water a day can be produced (this water to water system). The system also works with solar power and is applied at the moment a.o. in the Middle East. (<http://www.rainmakerww.com/>)

Nedap: Nedap has developed an automation process for livestock farming. They sell electronic technologies for the identification, feeding, milking, separating and for heat detection. Their smart tags and other devices measure the animal behaviour and condition and keep the tract of the individual animals. (<http://en.nedap-livestockmanagement.com/>)

Fedecom: Fedecom is a Dutch branch organisation for companies in technologies for dairy farming, agriculture, landscaping and horticulture. (<https://www.fedecom.nl/english/>)

4.2 Opportunities and strategies for Dutch companies

India offers a great market for Dutch companies that intend to export products and services in the Dairy sector. In the first chapter of this report, based on a report of YES Bank, it was shown that the consumer demand has an annual growth rate of 4%. This growth is induced by the increasing population size and the fast urbanization, leading to an increasing income and consumer's awareness, changing lifestyles and increasing expenditure on health issues.

Most of the milk in India (about 60%) is consumed as milk and about 40% is processed into various traditional and non-traditional products, such as: ghee, paneer, khoa, curd, (flavoured) yoghurt, butter, buttermilk, lassi, cheese, ice-cream or milk Powder. A new, growing niche market in India is the production of so-called 'A2 milk' by indigenous cows. This milk lacks a form of β -casein proteins, which would make it better digestible. In India many consumers are convinced that this milk benefits health. The milk is notably produced by indigenous breeds, which also produce many by-products for manure and ayurvedic medicines. Because of this growing movement for indigenous cows, these dairy products offer a remarkable higher margin to farmers.

As the new consumer demand is especially growing in cities, logistic chains become more important. This leads to a growing demand for new processing and post-processing methods on innovative packaging and cold chain, which offers new chances for processors and technology and service suppliers.

Although most of Dutch exporters aim at large scale, high technology and capital intensive dairy farming, most of the milk (around 70%) in India is going through so called 'unorganized channels', operated by local vendors or direct sales from producers to consumers. Only 30% is going through 'organized chains'. Furthermore, about 80% of the milk in India is being produced by family farmers, most of them have 2-8 cows. These are mixed farming systems, in which milk cows have an important function for providing a continuous cash flow for the farms, that also produce vegetables and/or contract farming of, for example, sugar cane. A part of these small scale farmers are now specializing on dairy farming, developing their farm in a medium sized dairy farm of 20-50 cows.

India is developing into an important Dutch trade partner. In 2015, the Dutch and Indian prime ministers gave a stimulus to the economic Indo-Dutch relations. The Dutch ministry actively supports Dutch companies that intend to expand or enter their Indian market, through the Embassy, agricultural attaché and consulates. The website of RVO of the Ministry of Economic Affairs provides information on doing business in India and possible



subsidies (<https://www.rvo.nl/onderwerpen/internationaal-ondernemen/landenoverzicht/india>). The Ministry points out the huge demand for knowledge and technology to improve efficiency and quality throughout the entire dairy chain and the integrated approach of the dairy chain which is needed.

However, the Indian market of small and medium sized dairy production also poses a challenge to Dutch companies. Indian culture is significantly different from Dutch culture. The position and status of the cow is special in India, with strict regulations on animal welfare and the slaughtering of cows is not accepted in traditional Hindu religion. The political system is often difficult to comprehend, as it comprises bureaucracy and informal networks. Legislation and cooperative structures are complicated and informal relationships are very important. Finally, the investment capacity of small and medium-sized farm is low and infrastructure is often not optimal. But these problems can be overcome as Dutch companies and knowledge institutes participating in the Family Dairy Tech project experienced.

A general, corporate strategy to reach this huge market of rural, small-medium scale customers might be inspired by the strategy of Hindustan and Thai Unilever (Mahajan, 2016) which can be summarized by:

- Train rural representatives.
- Develop grassroots distribution strategies through local markets.
- Offer extra services needed by rural customers.
- A well-developed marketing and advertising strategy using new channels and mobile technology/social media.
- Design products specifically designed for rural customers.
- Adapt the company's mind-set to the rural market.

During the Family Dairy Tech project, entrepreneurs and researchers from both India and the Netherlands came together and discussed a lot about their experiences, during formal meetings and valuable informal encounters and dinners. Based on these talks, ten advices for Dutch companies that want to explore, enter or expand opportunities for their business on the Indian market can be formulated for companies active in the Indian dairy market, based on small and medium sized farmers:

1. Paying attention to developing and maintaining a network is very important, but identify and collaborate with appropriate partner(s) is the key of market success.
2. To work in India successfully, Dutch companies need to have Indian employees, who know the Indian society, culture and bureaucracy. Indian alumni that were trained both in India and the Netherlands can be an asset to the company.
3. Family Dairy Farming is a new model for India which is still under development. Medium sized farmers are not used to make their own entrepreneurial decisions and still have to develop the competences to make their own decisions.
4. Educating customers how to effectively use the products and services offered, should be part of the value proposition (by the company or in collaboration with NGOs, consultancies etc.).



5. Indian customers expect that service is included in the product sold, so service that fits with the orientation of the Dutch companies should be part of the package that is offered.
6. In India: 'seeing is believing' so always add demonstrations, videos, graphs etc.
7. The Indian market is highly cost-sensitive, therefore think about innovative ways like leasing, renting, collective purchasing as alternative solutions for traditional selling of products and services.
8. Dairy farming is an integrated system in which all aspects are critical, so selling only one product/solution does not guarantee the benefit for the farmer. The return on investment for the farmer should be very clear and communicated well to the farmer.
9. Expectations management is crucial, do not sell products of which on beforehand is clear that they will not work under the specific circumstances. Farmers sometimes might tend to buy technology because of societal status. It will not contribute to farmers profit and harm the name of the company. Therefore, products and services have to be effective, robust and affordable for the specific circumstances of the customer. This requires 'frugal innovation'.
10. Mouth-to-mouth advertising is important, and role models and influential people in society are important. Not only invest in relations networks but also incorporate them in a well-designed marketing strategy!

The general conclusion is that Dutch companies should carefully consider and explore before they are going to enter the Indian market with new technologies and services, but that it is rewarding. The reward is financial, but also inspiring and motivational to explore new cultures and develop new relationships. There are no 'quick wins' and companies have to develop the market for their products, which could be a slow process and needs patience.



References

Agrawal, P. (April 2017). *Better housing for cows in Pune district: Benchmarking, challenges and solutions*. presentation at workshop, ADT, Baramati, Pune, India.

Agrawal, P., Regel, F. & Van Os, G. (December 2016). *Innovations in Barn Design*. The Netherlands: end project poster in English and Marathi, Saxion University of Applied Sciences.

Agrawal P., Regel, F. & Van Os, G. (July 2017). *Better housing for cows in Pune district, India*. Leeuwarden, the Netherlands: presentation at workshop, Dutch dairy campus.

Berg, J. (August 2016). *Textile technology for Dairy farms: how can fibre-reinforced composite materials improve the lives of heat-stressed dairy cows in India?*. The Netherlands: Bachelor thesis, Saxion University of applied sciences.

Boomkamp, J., Kruiper, T. & Te Dorsthorst, T. (April 2017). *Barn design 3.0: Wikihouse modular barn design*. workshop presentation at ADT, Baramati, Pune, India.

Boomkamp, J., Kruiper, T. & Te Dorsthorst, T. (April 2017). *Barn design 3.0: short video on modular barn design suitable for farmers in Pune district in India*. presented at workshop, ADT, Baramati, Pune, India.

Boomkamp, J., Kruiper, T. & Te Dorsthorst, T. (January 2017). *Wikihouse modular barn design*. The Netherlands: Internship report, Saxion University of applied sciences.

Boomkamp, J., Kruiper, T. & Te Dorsthorst, T. (December 2016). *Wikihouse modular barn design*. Leeuwarden, the Netherlands: poster presentation, workshop conducted at Dutch dairy campus.

Cooper, R. (2009). *Nutrition of Dairy Herds. Part 1-Maximising Dry Matter Intake*. Accessed 09 June 2017, at <http://www.nadis.org.uk/bulletins/nutrition-of-dairy-herds/part-1-maximising-dry-matter-intake.aspx>

Dhorde, S. (March 2016). *Cattle housing technologies of companies involved in the Family Dairy tech project*. Velp, the Netherlands: Bachelor thesis, Van Hall Larenstein University of Applied Sciences.

Fleuren, M. (2016). *An inventory of the dairy sector in Baramati, Pune district, Maharashtra state, India*. Project report RAAK Family Dairy Tech.

Giannakopoulou, D. (2017). *Animal Nutrition Handbook for Dairy Herd Management in Pune district family farms*. Project report RAAK Family Dairy Tech.

GTZ. (2006). *ValueLinks, manual, the Methodology of Value Chain Promotion*. Germany: GTZ.



Hulleman, A. (2017). *Producing maize silage in India*. Leeuwarden, the Netherlands: Bachelor thesis, Van Hall Larenstein University of Applied Sciences.

Hummels, L. (December 2016). *Better cow welfare*. poster presented at workshop conducted at Dutch dairy campus, Leeuwarden, the Netherlands.

Hummels, L. (April 2017). *Cooling cows for combating heat stress*. workshop presentation at ADT Baramati, Pune, India.

Hummels, L. (April 2017). *Cooling cows for combating heat stress*. The Netherlands: Bachelor thesis, Saxion University of applied sciences.

Ingale, R. (2017). *Untouched hygienic milk chain*. Velp: Bachelor thesis IAT, Van Hall Larenstein University of Applied Sciences.

Kangale, M. (2016). *Breeding program with Gir; Data collection system in small scale dairy farm; Market potential of milk products of Indigenous cattle and crossbred Holstein Friesian*. Velp, the Netherlands: CRV Placement report, Van Hall Larenstein University of Applied Sciences.

Kangale, M. (2017). *Development of an Integrated Animal Recording System for Breeding Purposes*. Velp, the Netherlands: Bachelor thesis, Van Hall Larenstein University of Applied Sciences.

Kapoor, R. (2014). *Indian cow, may your yield increase*. Accessed 21 May 2017, at: <http://www.thehindubusinessline.com/opinion/indian-cow-may-your-yield-increase/article5835726.ece>

Khadke, G. (July 2017). *Barn Design 2.0: Frugal innovation of family dairy barns in Pune district*. Velp, the Netherlands: Bachelor thesis, Van Hall Larenstein University of Applied Sciences.

Kondala, N. (July 2016). *Barn designs with the possibility to earn extra profit from vermicompost plant*. The Netherlands: Internship at Saxion University of applied sciences, report submitted to Van Hall Larenstein University of Applied Sciences.

Kondala, N. (2017). *Innovations in support of Dairy Farm Management – FDT farms Pune India*. Velp, the Netherlands: Bachelor thesis, Van Hall Larenstein University of Applied Sciences.

Ladhe, A. (2016). *Market research India*. Velp, the Netherlands: Uniform Agri Placement report, Van Hall Larenstein University of Applied Sciences.

Ladhe, A. (2017). *Developing New Rations for Better Milk Production (For RAAK Farmers)*. Velp, the Netherlands: Bachelor thesis, Van Hall Larenstein University of Applied Sciences.



- Marri, M. & Tingiira, J.B. (2017). *Tender document for untouched milk chain in Baramati*. Velp: Internal MSc APCM programme document, Van Hall Larenstein University of Applied Sciences.
- National Dairy Research Institute. (2012). *Regional Trends and Pattern in Milk Production in Maharashtra State*. Department of Dairy Economics, Statistics and Management, Karnal-132001 (Haryana).
- Nepal, Y. & Liban, J. (2017). *Tender document for local A2 milk chain in Baramati*. Velp: Internal MSc APCM programme document, Van Hall Larenstein University of Applied Sciences.
- Oldenbroek, K. & Van der Waaij, L. (2014). *Animal Breeding and Genetics for BSc students*. Accessed 15 February 2017, at: http://www.wur.nl/upload_mm/d/b/b/614bcc19-036f-434e-9d40-609364ab26da_Textbook%20Animal%20Breeding%20and%20Genetics-v17-20151122_1057.pdf
- Pagare, V. (2017). *Opportunities for introducing Herd Management Software of Uniform-Agri in India*. Velp, the Netherlands: Bachelor thesis, Van Hall Larenstein University of Applied Sciences.
- Patil, R. (2017). *Developing A1 & A2 milk value chains and business models*. Velp: Bachelor thesis IAT, Van Hall Larenstein University of Applied Sciences.
- Regel, F. & Pawle, P. (April 2017). *Barn roofing: alternative roofing material and heat simulation data*. workshop presentation, ADT Baramati, Pune, India.
- Regel, F. & Pawle, P. (December 2016). *Barn roofing*. poster presentation, workshop conducted at Dutch dairy campus, Leeuwarden, the Netherlands.
- Rajalaxmi B., Ajoy M., Adhikari S. (2017). *The importance of record keeping at livestock farms*. Retrieved may 02 2017, from Vikaspedia: <http://vikaspedia.in/agriculture/livestock/cattle-buffalo/importance-of-record-keeping-at-livestock-farm>
- Saha, A., Garica, O. & Mahmood, K. (2004). *Who is more competitive in the dairy chain in India -formal vs. informal*. *Institute of Farm Economics*. Braunschweig, Germany: Paper presented at Tropentag, 2004, FAL.
- Ten Berge, T. (2014). *Eye4Dairy Feed and Economy*. Leeuwarden, the Netherlands: Bachelor thesis, Van Hall Larenstein University of Applied Sciences.
- Weiss, B., n.d. *Optimizing and Evaluating Dry Matter Intake of Dairy Cows*. Accessed 09 June 2017, at: <http://www.wcds.ca/proc/2015/Manuscripts/Chapt%2013%20-%20Weiss.pdf>



YESBANK. (2016). *Dairy Sector in India*, New Dehli : Yes Bank and Embassy of Kingdom of the Netherlands

YESBANK. (October 2016). *States and Products*. Food and Agribusiness Strategic Advisory & Research (FASAR).

Zeschky, Widenmayer & Gassmann. (2011). Innovation in Emerging Markets. *Journal for Research-Technology Management, Volume 54, Issue 4: Innovation in Emerging Markets*.

Mahajan, V. (December 2016). *How Unilever Reaches Rural Consumers in Emerging Markets*. Harvard Business Review, <https://hbr.org/2016/12/how-unilever-reaches-rural-consumers-in-emerging-markets>.



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