SAARC DAIRY OUTLOOK

SAARC DAIRY OUTLOOK

SAARC AGRICULTURE CENTRE
SAARC Dairy Outlook

Compiled and Edited by
Dr. Md. Nure Alam Siddiky
Senior Program Officer
SAARC Agriculture Centre

SAARC Agriculture Centre
SAARCC Dairy Outlook

Contributors

Dr. A. K. Srivastava
Director and Vice Chancellor
ICAR-National Dairy Research Institute (NDRI)
Karnal-132 001 Haryana, India

Dr. A. Kumaresan
Senior Scientist (Animal Reproduction)
Livestock Research Centre
ICAR-National Dairy Research Institute (NDRI)
Karnal-132 001 Haryana, India

Dr. G. R. Patil
Joint Director (Academics)
ICAR-National Dairy Research Institute (NDRI)
Karnal-132 001 Haryana, India

Published in November 2015

ISBN: 978-984-33-9790-4

Published by
SAARCC Agriculture Centre (SAC)
BARC Complex, Farmgate, Dhaka-1215, Bangladesh
Phone: +880-2-58153152, Fax: +880-2-9124596
E-mail: sac@saarcagri.org, Web: www.saarcagri.org

Cover Designed by
Ms. Mafruha Begum, SPO (I&C)

Price
US$ 5.00 for SAARC countries
US$ 8.00 for other countries

Printed at
Natundhara Printing Press
277/3 Elephant Road (Kataban Dhal), Dhaka
Cell: 01711019691, 01911294855
Email: natundhara2014@gmail.com
Foreword

The role of livestock in livelihood, nutritional and food security of millions of people living in SAARC countries has been well understood. Among livestock, dairy animal assumes much significance since dairying is acknowledged as the major instrument in bringing about socio-economic transformation of rural poor and sustainable rural development. Unlike crop which is seasonal, dairying provides a stable, year-round income, which is an important economic incentive for the smallholder farmers. Dairying directly enhance the household income by providing high value output from low value input besides acting as wealth for future investment. It also offers a buffer income to the family during crop-vulnerable calamities. Till date, smallholder dairying is the backbone of dairying and contributes to more than 70 percent of the total milk produced in the region. However, in the recent past, several countries witnessed increase in income levels of the population, especially of large middle class that led to a spurt in demand of quality milk and milk products in the region. It is evident that without much transformation in the existing milk production system, we may not be able to meet the demand for milk and milk products in future. To meet the projected demand of milk and milk products, the region has to equip itself to witness the transformation in dairy sector from subsistence oriented to commercial/semi-commercial oriented activity. Such transformations, although not universal, are already taking place in few SAARC member countries. While promoting the commercialization of dairying in SAARC member countries, we have to exercise some mechanisms to protect the interests of smallholders since dairying is a part of livelihood for these poor people. Any mechanism which ignores livelihood issues would be inequitable and therefore may not find acceptance in the poorer regions of the world. Thus, by facilitating the large scale commercial dairying only, it may not be possible to obtain inclusive growth; however boosting the smallholder dairying as a whole and commercial dairying at identified areas would keep dairying as an instrument of inclusive economic development.

Milk processing in the region is still in primitive stage. The total share of the organized sector, cooperatives, government as well as the private sector is very less leaving a lion’s share of the total milk production in the hands of the unorganized sector. The untapped potential of the dairy sector in SAARC member countries is immense and opportunity to set up new ventures for value addition is great. In order to meet the growing domestic as well as export demand, the dairy
sector must increase its competitiveness in the global market place, by bringing about a qualitative transformation in the unorganized sector, which incidentally meets the entire demand for traditional dairy products, to ensure consumer safety. There is a need to upgrade the dairy value chain to eliminate inefficiencies and lower production and processing costs, while simultaneously increasing milk quality so as to meet domestic and international standards. The dairy industry must bridge the significant quality gaps that exist, meet higher quality standards and seize market opportunities, while defending its domestic market from high-quality imports. Therefore, major transformations in dairy sector are anticipated to impart greater competitiveness and opportunities for value addition.

In this document “SAARC Dairy Outlook” we sincerely made an attempt to compile the data related to dairying in different countries of SAARC region and situation analyses of input and delivery system for identifying the points of interventions to boosting dairy production and processing. In gist, this document narrates the facts about the current dairying in the SAARC member countries and envisages the priorities to make the dairying sustainable and more productive with the aim to cater the inclusive development of dairying in the region. It is hoped that this document will provide a wealth of information to the researchers, planners, entrepreneurs and other stakeholders for upliftment of dairy industry in SAARC member countries. I like to convey my sincere appreciation to Dr. M. Mujaffar Hossain, Professor, Bangladesh Agricultural University for editing the final version.

Dr. S. M. Bokhtiar
Director
SAARC Agriculture Centre
## Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Topic</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Importance of livestock in SAARC member countries</td>
<td>1</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Dairy animal population in SAARC member countries</td>
<td>8</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>Dairy animal breeds</td>
<td>23</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>Dairy animal production systems</td>
<td>32</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>Milk production in SAARC member countries</td>
<td>44</td>
</tr>
<tr>
<td>Chapter 6</td>
<td>Situation analysis of inputs for dairying</td>
<td>58</td>
</tr>
<tr>
<td>Chapter 7</td>
<td>Milk collection and marketing channels</td>
<td>67</td>
</tr>
<tr>
<td>Chapter 8</td>
<td>Strengths, weaknesses, opportunities and threats (SWOT) for dairy development in SAARC member countries</td>
<td>90</td>
</tr>
<tr>
<td>Chapter 9</td>
<td>Subsistence to commercial dairying: Key considerations</td>
<td>93</td>
</tr>
<tr>
<td>Chapter 10</td>
<td>Strategies for boosting dairy production</td>
<td>102</td>
</tr>
<tr>
<td>Chapter 11</td>
<td>Quality control in the traditional and commercial dairy sectors</td>
<td>111</td>
</tr>
<tr>
<td>Chapter 12</td>
<td>Diversification of dairy products by traditional and novel technologies</td>
<td>114</td>
</tr>
<tr>
<td>Chapter 13</td>
<td>Role of private sector and its collaboration with public sector</td>
<td>138</td>
</tr>
<tr>
<td>Chapter 14</td>
<td>Dairy development in SAARC member countries: The way forward</td>
<td>142</td>
</tr>
<tr>
<td>References</td>
<td></td>
<td>151</td>
</tr>
<tr>
<td>Sources of data</td>
<td></td>
<td>159</td>
</tr>
</tbody>
</table>
### List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Dynamics of dairy animal population in the world</td>
<td>12</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Contribution of SAARC member countries to total dairy animal population</td>
<td>13</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Distribution of individual dairy animal populations in different SAARC member countries</td>
<td>14</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Dynamics of dairy animal population in Afghanistan</td>
<td>15</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Dynamics of dairy animal population in Bangladesh</td>
<td>16</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Dynamics of dairy animal population in Bhutan</td>
<td>17</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Dynamics of dairy animal population in India</td>
<td>18</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Dynamics of dairy animal population in Nepal</td>
<td>19</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Dynamics of dairy animal population in Pakistan</td>
<td>20</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Dynamics of dairy animal population in Sri Lanka</td>
<td>21</td>
</tr>
<tr>
<td>Figure 11</td>
<td>World milk production in million tons</td>
<td>46</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Top 10 milk producing countries in the world</td>
<td>46</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Average individual animal milk production (kg/year) in different countries</td>
<td>47</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Contribution of different SAARC member countries to total milk production in the region in 2012 (FAO)</td>
<td>47</td>
</tr>
<tr>
<td>Figure 15</td>
<td>Contribution of different animals to total milk produced in the region</td>
<td>48</td>
</tr>
<tr>
<td>Figure 16</td>
<td>Trend in total milk production in SAARC member countries</td>
<td>48</td>
</tr>
<tr>
<td>Figure 17</td>
<td>Trend in milk production in individual SAARC member countries</td>
<td>49</td>
</tr>
<tr>
<td>Figure 18</td>
<td>Contributions of different animals to the total milk production in individual SAARC member countries</td>
<td>52</td>
</tr>
<tr>
<td>Figure 19</td>
<td>Individual animal milk productivity in SAARC member countries</td>
<td>53</td>
</tr>
<tr>
<td>Figure 20</td>
<td>Trends of individual animal’s milk productivity in SAARC member countries</td>
<td>57</td>
</tr>
<tr>
<td>Figure 21</td>
<td>Product-wise consumption pattern</td>
<td>71</td>
</tr>
<tr>
<td>Figure 22</td>
<td>Supply chain of Indian dairy industry</td>
<td>75</td>
</tr>
<tr>
<td>Figure 23</td>
<td>Milk marketing channel in Nepal</td>
<td>84</td>
</tr>
<tr>
<td>Figure 24</td>
<td>Milk marketing chain in Pakistan</td>
<td>86</td>
</tr>
<tr>
<td>Figure 25</td>
<td>Supply chain for milk in Sri Lanka</td>
<td>89</td>
</tr>
</tbody>
</table>
Figure 26: Buy-back model for effective use of male germplasm 104
Figure 27: The potential thrust areas in the Indian dairy industry for the PPP to intervene 140

List of Tables

Table 1: Annual growth rate of dairy animal population in SAARC member countries 22
Table 2: List of cattle/ types breeds as per SAARC Agriculture Centre study and FAO in different SAARC member countries 23
Table 3: List of buffalo breeds as per FAO in different SAARC member countries 28
Table 4: Yield gap analysis for milk production in cows (2011) 55
Table 5: Yield gap analysis for milk production in buffaloes (2011) 56
Table 6: Gross chemical composition of cow and buffalo milk 130
Table 7: Physical properties of buffalo and cow milk 132
Chapter 1

IMPORTANCE OF LIVESTOCK IN SAARC COUNTRIES

The livestock sector is one of the fastest growing segments of the agricultural economy, particularly in the developing world. Livestock are central to the livelihood and nutritional security of the poor community. The contribution of livestock to livelihoods of millions of people in SAARC member countries are well beyond the production for household consumption or for market. Besides their monetary benefit and providing a steady stream of food and revenues for households, Livestock provide employment to the family, act as insurance during crop failures, contribute to gender equality by generating opportunities for women, generates in situ fertilizers for enhancing the soil fertility, contributes to day-to-day expenses of the farm family. Recycle waste products and residues from cropping or agro-industries, supplies energy source for cooking and at places the number of livestock owned by a farmer determines his social status among the community. Although mechanization is taking place at greater speed in the world, still a major proportion of farmers in the region depend upon the draught power of livestock for farming. Thus any progress of livestock sector results in balanced development of the rural economy, particularly in reducing the poverty amongst the weaker sections, as the ownership of the livestock is more egalitarian compared to land and other productive assets. This is the sector where the poor contribute to growth directly instead of getting the trickle down benefit from growth generated elsewhere. The rural women play a significant role in animal husbandry and are directly involved in most of the operations relating to feeding, breeding, management and health-care of the livestock. However, in spite of the significant contribution of the livestock sector in socio-economic up-liftment of the resource poor farmers and the overall agricultural growth, full potential of this sector has remains untapped.
Livestock sector and national economy in SAARC member countries

In Afghanistan, more than 85% of population is dependent on agriculture and related activities for livelihood. Agriculture has been the mainstay of the people’s economy and agriculture sector in Afghanistan contributed 28% to the Gross Domestic Product (GDP) at 2010/11 market price. Livestock is an integral part of agriculture and majority of the farmers own one or more livestock species. Livestock products such as wool, milk and milk products, meat, skin, and fat are a main source of income for the farmers and a good food source for the families of farmers. Animals are the only source of income for nomads. The share of livestock in agriculture GDP during 2010-11 was 14% and the contribution of livestock sector to overall GDP was around 3.5%. The total milk production in Afghanistan was around 1.4 million tons in 2013 which consists mainly of cow milk followed by sheep and goat milk.

In Bangladesh, agriculture plays an important role in the national economy. The role of livestock sector is vital for the economic development of agriculture in the country. The contribution of livestock to National Gross Domestic Product (GDP) is around 2.6%, which constitutes to 13 percent in agricultural share. About 75% people indirectly rely on livestock for their livelihood and around 8% of total protein for human consumption comes from livestock. About 20 percent of the population is directly and 50 percent of the population is partially dependent on livestock sector. About 30 percent of the total tillage is still covered by livestock besides mechanical tillage. As per FAO estimates, there is a deficit of around 70% in milk. Statistics of Department of Livestock Services indicate that the domestic production of milk in Bangladesh was around 5.0 million tons in the fiscal year 2012-2013 against the demand of around 17.00 million tons.

In Bhutan, agriculture and livestock contribute to 45% of the country's GNP. According to SYB (2011) agriculture in 2010 contributed 16.8% to the total economy i.e. as measured by the Gross Domestic Product. It was also the single largest sector that provides livelihood to more than 60 percent of the population as per Labour Force Survey 2011. The productivity of livestock showed a slight increase from 1.04 percent in 2010 to 2.22 percent in 2011; however its share to GDP dropped to 3.81 percent in 2011 from 4.30 percent in 2010. Most farmers in dairy developed areas earn money by selling milk produced over and above the household needs.

In India, the livestock sector contributes nearly 25.6% of value of output at current prices of total value of output in agriculture, fisheries and forestry sector. The overall contribution of livestock sector in total GDP is nearly 4.11% at current prices during 2012-13. The value of output in 2011-12 from the livestock sector was Rs. 4,59,051 crores at current prices, out of which milk and milk products was to the tune of Rs. 3, 05,484 crores (66.5%). The current market size
of the dairy industry is Rs. 2.6 trillion and is estimated to grow up to Rs. 3.7 trillion by 2015. India became the largest producer of milk in the world almost 15 years ago, and today accounts for 17 percent of global milk production. The estimated milk production was about 133.7 million tons in 2012-13. India has the largest livestock population in the world with 57.3 percent of the buffalo and 14.7 percent of the cattle population. However, the Indian dairy sector is dominated by the unorganized sector comprising of 70 million rural households comprising largely of marginal and small farmers who own 70 percent of the country’s bovine herds, each dairy farmer milking fewer than five milch animals at his home. In the last few years, the surge in demand for dairy products is estimated to have been between 6 to 8 percent annually, which is almost double the growth rate of supply. There is an urgent need for the growth rate of the dairy sector to match the rapidly growing Indian economy. Despite being the one of the largest milk producing countries in the world, India accounts for a negligible share in the worldwide dairy trade.

In Nepal, livestock production is an integral part of the mixed-farming system. The livestock sector contributes about a third of agricultural GDP and 4% of total exports for the nation. The national average per family livestock holding includes 3.8 cattle/buffalo, 2.2 goats and 4.5 poultry, which is high compared with other countries. Moreover, the total population of yak and chauri (crossbred animals between yak and local hilly cattle) is about 60 thousand out of which 10 thousand are producing milk. The yearly productivity is, however, very low. The milk production data of Nepal shows that 1.38 million tons of milk while cow milk 0.40 million tons (28.87 percent) and buffalo milk 0.98 million tons (71.13 percent) has been produced in 2007-08. Of this volume, only about 10 percent of milk (138,873 MT) is produced by the formal sector dairies (FAO, 2010). Growth rate in milk production ranges from 2.2–5.3% per year with the highest growth in the eastern (4.01%) and far-western (5.3%) regions.

Pakistan is the fourth largest milk producer in the world behind India, China and the United States with annual production of 36.2 million tons from eight million farming households. The livestock sector constitutes 12% of the total GDP and accounts for 55.6% of agricultural GDP. Gross value addition of livestock has increased from Rs.756.3 billion (2012-13) to Rs.776.5 billion (2013-14), showing an increase of 2.7 percent as compared to last year. At the micro level, 35 million people living in rural areas rely on livestock for approximately 30-40% of their income. The dairy sector in Pakistan plays a significant role in the national economy with the value of the milk sector being more than that of the wheat and cotton sectors combined. The milk production is growing at the rate of 5% per annum. However, the growth is offset by a demand which growing by 15 percent. At present, the total estimated demand in terms of liquid milk is 43.2 million tons in the country. The country has been facing a domestic deficit in milk supply and
dried milk powder has been consistently imported for the past several years to bridge this gap.

In Sri Lanka, the agricultural sector contributes around 16.8 percent of National Gross Domestic Production (GDP). The livestock sub sector contributes around 1.2% of national GDP. Dairy sector is the most important of all livestock sub sectors because of the influence it makes on the rural economy. The domestic milk production only constitutes about 17 percent of the requirement and the rest is imported. According to Agriculture and Environment Statistics Division of Sri Lanka, the annual milk production in Sri Lanka was 0.29 million tons 2012, which is only around 25 to 30 percent of the total national requirement. The country had imported 84,000 MT of milk products during 2011 to meet the requirement. The government attention is most focused on the dairy sub sector; to develop this sector into a ‘local industry’. Priority is therefore given for the dairy development in public sector investment programmes and several incentives offered to the private sector to engage in dairy sector.

**Role of livestock in food and nutritional security**

Livestock contribute around 12.9 percent of global calories and 27.9 percent of protein directly through provision of meat, milk, eggs and offal. Animals are an important source of food, particularly of high quality protein, minerals, vitamins and micronutrients. Livestock supply huge amount of essential nutrients to the human population. The importance of dietary animal protein can be well recognized because it contains essential amino acids that are deficient in cereals. Eating even a small amount of animal products corrects amino acid deficiencies in cereal-based human diets, permitting more of the total protein to be utilized because animal proteins are more digestible and metabolized more efficiently than plant proteins. Meat, milk and eggs provide proteins with a wide range of amino acids. Animal protein match human needs as well as bio-available micro-nutrients such as iron, zinc, vitamin A, vitamin B12 and calcium in which many malnourished people are deficient. Increasing livestock production is expected to have significant impact on food supply to these people since many poor small holders will have direct access to more food of livestock origin. Increased production will keep livestock product prices down and allow low income group’s access to such food and increased domestic production will reduce imports and save foreign exchange which can then be diverted to productive investment and indirectly contribute to food security. In spite of such contributions from the livestock sector to the national economy and household food and nutritional security, we need to relook several issues of animal production and management in a holistic way to make the SAARC member countries a front runner in the world.
An old adage says that “land rich in livestock will never be poor and a land poor in livestock can never be rich”. Indeed, livestock are an integral component of agriculture in SAARC member countries and make multifaceted contributions to the growth and development of the agricultural sector. The role of livestock in providing food and nutritional security at grass root levels is very significant since livestock production is an important secondary occupation for livelihood and nutritional security of the people. In the SAARC region, smallholder farming comprising of landless, small and marginal farmers is very common, of which a majority of households rear livestock either as a mainstay and/or complementary to crop production (Ahuja and Staal, 2012). It is a common fact that the poor tend to be more towards livestock production than crop production as it has direct impact on poverty reduction since livestock supply food, provide source of income, generate employment and forms an important input for crop production and agricultural operations.

Livestock are often the most important cash crop for a significant proportion of population in the region. Unlike agricultural crops which do not provide round the year income, livestock offers day-to-day income. This disposable income from livestock is important for purchase of agricultural inputs and other family needs. Cash can be generated from sales of livestock products regularly (milk, eggs) or sporadically (live animals, wool, meat, hides) or from services (draught, transport). Livestock can be increased economic stability to farm households, acting as a cash buffer (small stock), a capital reserve (large animals) and as a hedge against inflation. In mixed farming systems, livestock reduce the risk through diversification of production and income sources and there is therefore a much greater ability to deal with seasonal crop failures and other natural calamities. Livestock also represent liquid assets which can be realized at any time, adding further stability to the production system. As the human population increases, the demand for employment generation is also increasing. Livestock production offers an avenue for food security oriented self employment to unemployed youths and women. Women often have control of livestock and of the income they provide, which has had positive consequences for household nutrition.

In addition to contributing directly to food supply through provision of their own products, livestock contribute indirectly by supporting crop production with inputs of manure and traction. Manure is known to be better than artificial fertilizer for soil structure and long term fertility. Integration of livestock and crops allows for efficient recycling of nutrients through use of crop residues and by-products as animal feeds and for animal manure as crop fertilizer. Cattle dung contains about 8 kg of nitrogen, 4 kg of phosphate and 16 kg of potash per tons of dry matter. In addition, manure returns organic matter to the soil, helping to maintain its structure as well as its water retention and drainage capacities. The
use of dung as fuel is also important in some parts of the world. For instance, in India, the value output from the dung of livestock during the year 2008-09 at 2010 price was 156 billion rupees.

**Dairying: an important area of intervention**

Food security exists when all people at all times have access to adequate levels of safe, nutritious food for an active and healthy life. The livestock sector is important to food security, not only for rural smallholders who rely directly on livestock for food, incomes and services, but also for urban consumers, who benefit from affordable high-quality animal-based food. Like other livestock the dairy animals play an important role in all four main dimensions of food security: availability, access, stability and utilization.

Dairying is acknowledged as the major instrument in bringing about socio-economic transformation of rural poor in developing countries. Dairy industry provides newer avenues for employment, both direct and indirect, and improves the nutritional standards of people. Dairy cattle/buffaloes have an immense contribution for sustainable rural development as unlike crop which is seasonal, dairying provides a stable, year-round income, which is an important economic incentive for the small farmer to take up dairying. Milk plays a major role in reducing poverty and is a source of nutritious food in rural and urban population.

For the small-scale producer milk is a key element for household income and food security and is a regular source of income for rural families and their survival. FAO estimates that for every 100 litres of milk produced locally, up to five off farm jobs are created in related industries like collecting, processing and distribution. Daily one glass of milk to the children in Asia can contribute tremendously to improving the nutritional levels in the region. Thus focused attention on dairy development would not only improve the milk production but also enhance the livelihood and food security of population.

Ensuring food security have to be an issue of great importance for SAARC member countries where a considerable proportion of the population is estimated to be absolutely poor and significant proportion of children malnourished in one way or another. Food security means ensuring a sustainable supply of food at affordable prices that meets existing dietary preferences. Food security is a complex issue with both global and local dimensions that are intimately linked together. The two most important factors that determine the access of a household to food are household income and prevailing prices of essentials. Since milk and milk products are the most preferred food across the region irrespective of religion and socioeconomic status the supply of dairy products has to be addressed as part of any debate on food security.
Currently the global milk demand is growing by 15 million tons per year, mostly in developing countries. This increased volume of milk is being produced by small-scale dairy farmers, and millions of jobs per year may be created in primary production. This presents a unique opportunity for building up a sustainable dairy chain that sources milk from smallholder dairy farmers to meet not only the demands of local consumers but also those of the world market. While capitalizing on this opportunity could generate significant wealth in rural areas and provide benefits to all stakeholders involved in the dairy value chain, it calls for a sound dairy development strategy. Since smallholder dairying is considerably affected by factors such as resource access, service delivery, food safety standards as well as national and international subsidies, effective strategies are to be evolved considering all these factors. If the technological competence of the rural people in dairying is substantially improved, it would not only improve the self employment and also enhance the rural economy and livelihood. The importance of dairy animals are shown in following chart.
Chapter 2

DAIRY ANIMAL POPULATION IN SAARC COUNTRIES

The SAARC region has emerged as a major player in global dairy production and consumption. Aggregate consumption gains in dairy products over the past decade have exceeded twice the annual global average. The rising demand for milk is developing a shift in the dairy sector from subsistence to a market-oriented with higher input needs. Unlike developed countries where the number of dairy farms are decreasing while the number of heads per farm is increasing, in SAARC member countries, smallholder farmers owns a majority of dairy animals, with an average of 2-10 cows per household and contributes to a major chunk of milk produced in the region. It is well known fact that SAARC member countries have large population of milch animals, but in most of the countries the dairy production is far below their national requirement due to low productivity of dairy animals. Understanding the dynamics of dairy animal population is the basic requirement for evolving strategies for dairy development. This chapter deals the dairy animal resources in SAARC member countries and depicts their dynamics in context of milk production in the region.

The dairy animal population in the world including cattle, buffalo, sheep, goat and camel was 3534.63 million during 2011. Among the dairy animals, cattle dominated with 1399.9 million heads followed by the sheep which was 1043.7 million heads. While the cattle population more or less was increasing at slow pace, the buffalo population increased steadily from 164.11 million in 2000 to 195.3 million in 2011. The dynamics of dairy animal population across the globe is given in figure 1.

During 2007, the total dairy animal population in SAARC member countries was 745.11 million accounting to 21% of the world’s milch animal population. About 25% of world’s cattle and buffaloes, 15% of the sheep and goat, and 7% of the camel were present in SAARC member countries (Figure 2). Among the SAARC member countries, India had huge dairy animal population with 517.08 milion heads followed by Pakistan with 138.12 million heads. India accounted for 69.4% of the total dairy animal in the region, while Pakistan accounted for 18.54%. The dairy animal population in Afghanistan, Bangladesh, Bhutan, Nepal and Sri Lanka all accounted for 12.06% of the total dairy animal population in the SAARC member countries. The distribution of individual dairy animal populations in different SAARC member countries are depicted in figure 3.
Population dynamics

Afghanistan
The major dairy animals of Afghanistan are cattle, sheep and goat while camel also accounts to a minor portion. The cattle population increased steadily from 3.63 million in 1967 to 4.72 million in 2010. Similarly the sheep population also increased from 2.15 million in 1967 to 12.28 million in 2010. During the corresponding period, the goat population increased from 3.19 million to 5.81 million and the camel population decreased from 0.3 million to 0.2 million. Except camel all other dairy animals showed a positive trend in population growth during the last 4-5 decades. Overall, the total dairy animal population showed an increasing trend from 1967 to 1996, which declined sharply in 2003; after 2007 there has been a continuous and positive growth in total dairy animal population however the population of dairy animals has not reached the level documented during 1996. The dynamics of dairy animal population in Afghanistan is given in figure 4.

Bangladesh
During the period from 1980 to 2010, the population of cattle and buffalo increased from 22.03 million to 26.85 million in 2010. Similarly, the sheep and goat population together reached to 28.27 million in 2010 from 9.8 million in 1980. The trend in total dairy animal population showed a progressive positive growth from 1980 to 2002, however it started declining thereafter and continuing to decrease till 2010. While the cattle and buffalo population either increased on remain more or less constant, the sheep and goat population fluctuates heavily leading to changes in the dynamics of total dairy animal population in the country. The dynamics of dairy animal population in Bangladesh is given in figure 5.

Bhutan
Bhutan houses a very small population of dairy animals in the region. The major dairy animals are cattle, buffalo, sheep, goat and yaks. The cattle population including yaks more or less remained same with minor fluctuations from 1995 to 2010. The population of cattle and yak was 0.37 million in 1995 while the corresponding figure in 2010 was 0.38 million. The buffalo population showed a decreasing trend from 1995 to 2000 (from 0.012 million to 0.012 million) and thereafter it decreased to 0.010 million in 2008 and continued at that level till 2008. The sheep population also showed a decreasing trend from 1995 onwards till 2010 except for the year 2003 when it reached 0.03 million. The sheep population decreased from 0.03 million in 1995 to 0.012 million in 2010. Unlike buffalo and sheep population, the goat population decreased from 0.035 million in 1995 to 0.021 million in 2005, which then showed an increasing trend continuously till 2010 when the goat population reached to 0.04 million in 2010. Overall, the total milch animal population showed an increasing trend from 1995
to 2003 (from 1.64 million to 2.29 million) and then decreased continuously till 2010 when the total dairy animal population reached 1.86 million (Figure 6).

**India**

As indicated earlier, India accounts for around 69% of the total dairy animals (including sheep) in the SAARC member countries. The major dairy animals in the country are cattle, buffalo and goats, however at some pockets camel and sheep milk is also consumed. The cattle population increased steadily from 155.3 million in 1951 to 199.08 million in 2007, which then declined to 190.9 million in 2012. The buffalo population witnessed a steady positive growth from 1951 to 2012. The buffalo population in 1951 was 43.4 million, which increased substantially to 108.7 million in 2012 without any decrease at any point during the period. The sheep (although not a major dairy animal) population more or less remained similar from 1951-1977, which then increased steadily to 71.6 million in 2007 and then decreased to 65.07 million in 2012. Unlike sheep population, the goat population increased steadily from 1951 to 2007 (from 47.2 million to 140.54 million) and thereafter declined to 135.17 million in 2012. The camel population in 1951 was 0.6 million, which increased to 1.1 million in 1982 and decreased steadily and reached 0.4 million in 2012. The total dairy animal population showed a steady increase from 1951 to 2007. The dynamics of dairy animal population in India is given in figure 7.

**Nepal**

The cattle population remained more or less same from 1997 to 2012 in Nepal. The cattle population was 7.04 million in 1997, which increased slightly to 7.24 million in 2012. Unlike cattle population, the buffalo population showed a steady increase over the period. The buffalo population in 1997 was 3.41 million, which increased to 5.13 million in 2012. Like cattle population, the sheep population also remained more or less same during the period 1997-2012. Goat population has witnessed a steady positive growth from 1997 to 2012. The population of goat in 1997 was 6.08 million which increased to 9.51 million during 2012. Total dairy animal population showed a steady increasing trend from the period 1997 to 2012 (Figure 8).

**Pakistan**

Although, buffalo, cattle, sheep, goat and camel are contributing to milk production in the country, cattle and buffalo are considered as major dairy animals and are always mainly focused. Cattle and buffalo population showed a steady growth during the period 1961-2011. The cattle population in 1961 was 11.2 million, which increased substantially to 36.9 million in 2011. Similarly, the buffalo population in 1961 was only 6.7 million, which increased to 32.7 million
in 2011. Between sheep and goat, the goat population witnessed a substantial increase during the period. In 1961, the goat population was only 8 million, which increased to 63.1 million in 2011. The sheep population also increased from 8.7 million to 28.4 million during this period. The camel population was 0.59 million in 1961, which increased to 1.05 million in 1996 and decreased to 0.82 in 2001 then reached 1 million in 2011. Overall the total milch animal population showed a steady increasing trend during the period from 1961 to 2011. The dynamics of dairy animal population in Pakistan is given in figure 9.

**Sri Lanka**

The major dairy animals in Sri Lanka are cattle, buffalo and goats. The cattle population more or less remained stable during the period from 2003 to 2012. The population of cattle was 1.15 million in 2003, which increased slightly to 1.24 million in 2012. The buffalo population showed a steady increase during these periods. The buffalo population was 0.28 million in 2003, which increased to 0.41 million in 2012. The goat population also did not vary much between the periods from 2003 to 2012. The population of goat was 0.41 in 2003, which decreased slightly to 0.38 in 2012. The total dairy animal population marginally increased during the period from 1.84 million to 2.03 million heads (Figure 10).

**Growth rate of dairy animal population**

For analyzing the Annual Growth Rate (AGR) of dairy animal population, the period was divided into two periods viz., 1992-2002 and 2003 to afterwards. In Afghanistan, the AGR of cattle was positive during both the periods but the rate was higher during the period 2003-2010. The AGR of goats during both the period were negative while the AGR of sheep was negative during 1996-2002, which turned positive during 2003-2010. In Bangladesh, the AGR of cattle and buffalo were positive during both the period however the AGR of sheep and goat population was negative during 2002-2010. During the period 1992-2002, population of all the dairy animals except sheep showed a positive AGR in Bhutan, however during the period 2003-2010, all dairy animals except goat had negative growth rate. Both India and Pakistan had positive AGR during both the periods. The AGR of cattle, buffalo and goat was higher during the period 2001-2012 in Pakistan. In Nepal, except sheep all other dairy animals had a positive growth during both the periods. All the dairy animals had a negative AGR in Sri Lanka during 1992-2002 while the AGR of cattle and buffalo was positive during 2003-2012 (Table 1).

Overall, the population of dairy animals in SAARC member countries, during last few decades, showed a positive growth indicating that the population of dairy animal is increasing in a steady pace. While increasing population of dairy animals is expected to affect the carrying capacity of the available land, it also
draws the attention of the policy makers to evolve suitable policies and strategies to transform the “Animal Population Driven Dairying” in SAARC member countries into “Technology Driven Dairying” for sustainable use of resources that are already shrinking and to make dairying more productive and profitable.

Figure 1: Dynamics of dairy animal population in the world
Figure 2: Contribution of SAARC member countries to total dairy animal population in the world
Figure 3: Distribution of individual dairy animal populations in different SAARC member countries
Figure 4: Dynamics of dairy animal population in Afghanistan
Figure 5: Dynamics of dairy animal population in Bangladesh
Figure 6: Dynamics of dairy animal population in Bhutan
Figure 7: Dynamics of dairy animal population in India
Figure 8: Dynamics of dairy animal population in Nepal
Figure 9: Dynamics of dairy animal population in Pakistan
Figure 10: Dynamics of dairy animal population in Sri Lanka
Table 1: Annual growth rate of dairy animal population in SAARC member countries

<table>
<thead>
<tr>
<th>Animal</th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>Bhutan</th>
<th>India</th>
<th>Nepal</th>
<th>Pakistan</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>0.07</td>
<td>3.38</td>
<td>0.20</td>
<td>0.75</td>
<td>0.42</td>
<td>-0.67</td>
<td>0.77</td>
</tr>
<tr>
<td>Buffalo</td>
<td>--</td>
<td>--</td>
<td>-0.02</td>
<td>-0.2</td>
<td>9.09</td>
<td>-1.85</td>
<td>1.18</td>
</tr>
<tr>
<td>Goat</td>
<td>-2.31</td>
<td>-2.53</td>
<td>3.95</td>
<td>-5.78</td>
<td>6.02</td>
<td>7.41</td>
<td>0.69</td>
</tr>
<tr>
<td>Sheep</td>
<td>-7.50</td>
<td>4.95</td>
<td>1.96</td>
<td>-2.61</td>
<td>-4.44</td>
<td>1.44</td>
<td>3.28</td>
</tr>
</tbody>
</table>
Chapter 3

DAIRY ANIMAL BREEDS

The first report on State of World’s Animal Genetic Resources published by the FAO in 2007 indicated that 9% of breeds were extinct and 20% are under risk. Further 36% of the breeds were classified under Unknown status. The report indicated that only 35% of world’s breeds are enjoying not at risk status, which is an alarming situation for the entire world. SAARC member countries harbor a good number of indigenous breeds of dairy animals. These valuable animal genetic resources have been developed over a period of thousands of years through natural selection and human intervention, therefore, well adapted to their respective habitat. However, most of the countries, for the genetic improvement of these livestock resources, import exotic germplasm leading to dilution of local breeds. The adaptation of temperate exotic breeds needs much more sophisticated and scientific management under tropical climates. There has been a change in the utility pattern of these genetic resources which has created a stiffer competition to the local breeds for their survival. Therefore, genetic erosion is a serious concern and a number of local breeds are at the risk of extinction. The breeds of cattle in SAARC members countries as recognized by the FAO are given in table 2.

Table 2: List of cattle/ types breeds as per SAARC Agriculture Centre study and FAO in different SAARC member countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Breeds/ Types</th>
<th>No. of breeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Afghan, Kandahari, Konari, Kunari, Shakhansurri, Sistani, Watani</td>
<td>7</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Red Chittagong, Faridpur, Madaripur, Munshiganj, North Bengal Grey, Pabna</td>
<td>6</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Bajo, Jaba, Jatsa, Langu, Nagamee</td>
<td>5</td>
</tr>
<tr>
<td>India</td>
<td>Alambadi, Amritmahal, Bachaur, Bargur, Bijnharpur, Brownind, Cutchi, Dangi, Deoni, Devarakota, Devni, Frieswal, Gangatiri, Gaolao, Ghumsuri, Goomsur, Gujamavu, Hallikar, Jellicut, Jersind, Kankrej, Kappiliyan, Karan Fries (eng.), Karan Swiss (eng.), Kenkatha, Khamala, Khasi, Kherigarh, Krishna Valley,</td>
<td>60</td>
</tr>
</tbody>
</table>
It is essential to understand the breeds present in the SAARC member countries and their capabilities for evolving strategies for germplasm exchange and other dairy development activities in the region. In this regard, important dairy animal breeds present in different SAARC member countries are elaborated here.

**Cattle**

**Afghanistan**

There are well-known four local/indigenous cattle breeds. They are Kandahari, Kunari, Sistani and Watani. The Kandahari and Kunari breeds are the high in population and these types of cows are known to be among the best milky/dairy of local cattle in the country (Mustafa Zafar, [http://afghanag.ucdavis.edu/c_livestock/reports/Rep_Livestock_Report_Afgh_Livestock_FAO.pdf/view](http://afghanag.ucdavis.edu/c_livestock/reports/Rep_Livestock_Report_Afgh_Livestock_FAO.pdf/view)).

The Kandahari breed is named after the genesis place- the Kadahar province. It is the oldest and one of the best native breeds in the country. The Kandahari is better adapted to the hotter areas of the south and west, shows such qualities as good constitution, resistance to diseases and produces more milk. The lactation milk yield is estimated to be 1200 - 2000 kg. The average lactation period is 183 days and calving interval is 448 days. The offspring produced by crossing Kandahari cattle with Holstein and Brown Swiss cattle has been reported to perform well.

Kunari breed was developed in Kunar province were notable for their adaptability and high milk fat content 4.0-4.5% (the best cows produce milk with 6 % fat). The daily milk yield of individual cows may increase up to 10-12 litres and for
this reason they are being used for crossing with the Jersey breed. It is a good dairy breed and noted for their ability to acclimatize in various areas like central and mountainous provinces and they are reported to be resistant to infectious diseases due to their strong constitution. The average lactation period is 230 days in average and calving interval is 380 days.

Sistani breed is found in Sistan Lake near the border between Afghanistan and Iran. This breed also has a good adaptation with tropical climate. The sex maturity age of these cattle is 3-4 years with medium and large body size. The daily milk yield is 3-5 litres per day with 3.0-4 % of fat content.

Watani (Native) breed is reported to be evolved over the time as a result of crossbreeding between Kandahari and Kunari cattle. The population of these cattle is more than the population of other breeds in the country. The daily milk yield is around 3-4 litres per day with 3.5-4 % fat content.

**Bangladesh**

Two major types of cattle dominate the Bangladesh dairy industry. Crossbred cattle constitute about 20% and are mainly produced by breeding local non-descript zebu cows and heifers predominantly with Holstein Friesian and Sahiwal bulls. Although local cattle have never been described as specific breeds, four types of cattle are considered to have the potential to develop into breeds. The most potential is with Red Chittagong Cattle. With good feeding and health care, these cows could produce 800-1000 litre milk/240-260 day lactation. Other potential cattle are Pabna milking cattle, Munshigang cattle, North Bengal Gray and Deshi. It is high time to characterize these animals and other population that could deserve a breed status and document them as recognized breeds so that suitable breeding policies can be evolved. Initiatives have already been taken in this regard however it needs to be speeded up.

**Bhutan**

Nublang is the native cattle breed of Bhutan, with its original home tract in Haa Sangbeikha of Western Bhutan. Nublang are stabilized breed that has evolved from crossing of humped cattle of Indian plains with that of humpless cattle migrated to southern slopes of Himalayas from Tibet. It is most adapted to a wide range of agro-climatic conditions, disease resistant, has good foraging abilities and survives under adverse nutritional conditions. They are more suitable for smallholder dairy production system and are the main base population for cross breeding programme with exotic breeds (Jersey and Brown Swiss). The average milk production of Nublang cattle has been reported to be around 3.5 litres /day (SA PPLPP, 2009).

Other dairy cattle breeds in the country are Jersey pure and cross, Brown Swiss pure and cross and Mithun cross. Brown Swiss crossbreeds are found in the higher altitudes of the temperate region, whereas Jerseys are more prevalent in the
lower temperate and subtropical regions of the country. The Mithun crossbreeds are more common in the lower temperate and subtropical regions.

The milk production of the local cattle are relatively low with a yield of 393 liters per lactation while crossbred cattle have a higher yield with 1299 litre/ lactation on average for the Brown Swiss Cross and 1479 litre/ lactation for the Jersey cross at the small holder farm level.

**India**

India is well known for its vast repository of dairy animal germplasm. The FAO has recognized 60 dairy cattle breeds from India. However the Indian nodal agency, the National bureau of Animal Genetic Resources has registered 37 breeds of dairy cattle. Among the cattle breeds 5 breeds are classified under Milch breeds and the remaining are either draft purpose or dual purpose. The indigenous milch breeds of India are having good potential of milk production. Such breeds are mostly evolved in North-West part of the country. The lactation milk yield of these breeds varies between 1200-3000 litres or even more. Such breeds are also used for grading up of non-descript cattle in different parts of the country for improving their milk productivity.

Gir cattle are distributed in Junagarh, Bhavnagar, Amreli, Rajkot districts of Saurashtra region of Gujarat. Animals have large body size and are known for tolerant to stress conditions, capacity for yielding more milk with less feed and is resistance to various tropical diseases. The breed has been used in many countries for genetic improvement of their local cattle. The average milk yield of Gir cows is 2000 kg in a lactation period of 300 days.

Rathi cattle are distributed in Bikaner, Ganganagar, Jaisalmer districts of Rajasthan. It takes its name from the pastoral tribes called Raths. Animals are medium size and tolerate heat and drought and resistance to diseases. The average milk yield is more than 700 kg in a lactation period of 230 days.

Red Sindhi cattle are distributed in organized farms. Animals are medium size and very compact. The average milk yield is 1800 kg in a lactation period of 300 days.

Sahiwal cattle is probably the best dairy Zebu cattle breed of the world and was originated from the Montgomery hills of Pakistan. Distributed in Ferozepur, Amritsar districts of Punjab and Hanumangarh and Ganganagar districts of Rajasthan. Animals are heavy with capacious udder. The average milk yield is 2300 kg in a lactation period of 320 days.

Tharparkar cattle is evolved in Thar desert from which it derives its name. The home tract of this breed is the Tharparkar district of south-east Sindh Provinance of Pakistan. Distributed in Jodhpur, Barmer, Jaiselmer districts of Rajasthan and adjoining parts of Pakistan. Animals are medium size with compact body
conformation with large and capacious udder. The average milk yield is 1600 kg in a lactation period of 290 days.

Nepal

In Nepal, six indigenous cattle have been characterized and performance evaluated. They have their unique nature and are considered to be resistant against diseases and parasites. These breeds include Lulu cattle, Achhami, Siri, Khaila, Terai and Pahadi.

Lulu cattle, the only humpless indigenous cattle breed found in mountainous region are also considered to have potentiality to produce in poor management conditions. The average milk productivity of Lulu cattle has been reported to be around 195 kg in 180-210 day lactation length with average calving interval of 18 months. Achhami cattle, the smallest cattle breed is found in western hill districts of Nepal and they are capable of producing milk compared to their body size in adverse environmental conditions. The average milk productivity of Achhami cattle has been reported to be around 225 kg in 180-270 day lactation length. Terai and Pahadi cattle produce around 250 kg per lactation. The exotic cattle breeds used for crossbreeding of indigenous cattle. Jersey and Holstein Friesian are the two primary breeds of dairy cattle used for crossbreeding and up gradation of indigenous/nondescript cattle.

Pakistan

Dairy type cattle of Pakistan comprise of two well documented and internationally recognized breeds viz., Sahiwal and Red-Sindhi. These have been used for cross breeding with temperate breeds of dairy cattle by several countries. Cholistani is a less recognized breed of dairy cattle in the country. Tharparkar (or Thari) and Kankrej are the two dual-purpose breeds that have reasonable potential for milk production as well as draught work (Hasnain and Usmani, 2006). In addition, there are about one million crossbred cattle mostly as a result of crossing the nondescript local cattle mainly with Holstein-Friesian.

Sahiwal cattle are in great demand in several countries because of their resistance to ticks and high temperature and reasonable dairy potential. The average milk production ranges from 1500 to 2200 kg/lactation with the lactation length of 270-300 days. Red-Sindhi cattle have been imported by several countries to improve the dairy potential of local cattle breeds. Milk yield per lactation varies from 1500 to 2000 litres with the lactation length of 270-290 days. Cholistani breed is considered to be the ancestors of Sahiwal breed. They are medium sized animals and the average milk production is around 1800 liters standardized for 305 days (Khan et al., 2008).

The Tharparkar breed has been named after the district from which it originates and very well adapted to the extreme climatic conditions and feed scarcity of their
home tract. Cows are fairly good milk producers. Kankrej is another dual-purpose breed with dairy potential lesser than Tharparkar breed. Original home tract of this breed is Indian Gujarat.

**Sri Lanka**

The indigenous native cattle population in the country, although produce less quantity of milk, are highly adapted to the local conditions. In the past, many different breeds of Indian origin (Sahiwal, Sindhi, Haryana, Tharpakar, Gir) as well as animals of European origin (Holstein Friesian, Ayrshire, Jersey, Australian Milking Zebu and Shorthorn) have been imported to the country for using in cross breeding programs. At present, Australian Friesian Sahiwal (ASF) is used in breeding programs in the country and a pure herd of AFS is maintained. The preference of breed varies with the agro-climatic zone of the country.

**Buffalo**

Within the SAARC member countries, buffaloes are mainly found in Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka where they are used either for milk production or draught purposes or both. Buffaloes occupy a unique place in the dairy production scenario because of their ability to perform under low input production system. The breeds of buffalo as recognized by the FAO are given in table 3.

<table>
<thead>
<tr>
<th>Country</th>
<th>Breeds</th>
<th>No. of breeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>Native buffaloes</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>Murrah, Nili Ravi, Banni, Assami, Bhadawari, Chilka, Jaffabadi, Mehsana, Kalahandi, Manda, Marathwadi, Nagpuri, Pandharipuri, Toda</td>
<td>14</td>
</tr>
<tr>
<td>Nepal</td>
<td>Lime, Parkote, Gaddi</td>
<td>5</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Azi Kheli, Nili, Ravi, NiliRavi</td>
<td>4</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Lanka, Mannar, Tamankaduwa</td>
<td>3</td>
</tr>
</tbody>
</table>

There are 13 NBAGR registered breeds of buffaloes present in India. Many of these buffalo breeds are producing good quantity of milk with high fat percent. Among all the buffalo breeds, Murrah is considered as the best dairy buffalo breed. The following are the details of the buffalo breeds available in India along with their milk production capacity.

- Banni buffaloes are distributed in Kutch region of Gujarat. These are known to have adapted to drinking water only once in 24-hours because of saline soil and scarcity of drinking water in their native tract. They have big frame and
deep body conformation with capacious udder, and thick prominent milk vein. This breed is famous for their high milk yield and capability to survive in the harsh climate of desert.

- Bhadawari buffaloes are distributed in Uttar Pradesh and Madhya Pradesh. This breed is famous for highest fat content in its milk. Milk yield is around 800 kg per lactation with the average fat content of 13%.

- Chilika buffaloes are found in nearby villages around Chilika Lake in Odisha. They spend more than 12 hours a day in lake and graze throughout the night in marshy land of the lake, feed on submerged weeds and aquatic vegetations in the lake. In the morning buffaloes are habituated to come to owner's home for drinking fresh water. Milk yield is around 500 kg per lactation with the average fat of 8.7%.

- Jaffarabadi buffaloes are distributed in Saurashtra region. Jaffarabadi animals are strong but relatively of loose body conformation. It is the heaviest of all Indian buffaloes. They are unique in their massive physique, long horns curved upwards at the tip forming a ring like structure in a characteristic fashion specific to the breed. Milk yield is around 2200 kg per lactation with the average fat of 7-8%.

- Kalahandi buffaloes are distributed in Hilly areas of Nuapada district and Kalahandi district of Odisha. Kalahandi animals have medium sized with compact body conformation and prominent milk vein. Milk yield is around 500 kg per lactation with the average fat of 8-9%.

- Marathwadi buffaloes are distributed in Maharashtra. The animals of this breed have medium to light built body with compact conformation, well developed udder and medium sized funnel shaped teats. Marathwadi animals are well adapted to hot and humid conditions. Milk yield is around 950 kg per lactation with the average fat of 4-5%.

- Mehsana buffaloes are distributed in Gujarat. Animals are medium sized with well proportionate body conformation, milk vein conspicuous and voluminous and udder is attached high in the back with well developed teats. These animals have good milk producing capacity and known for regular breeding with high breeding efficiency and persistent milker. Milk yield is around 1500-2700 kg per lactation with the average fat of 7%.

- Murrah buffaloes are the best dairy breed of buffalo in the world. They are distributed in Haryana, Punjab and Delhi. These animals have massive frame, attractive appearance and deep body conformation. They have capacious udder and long teats. The population of this breed is maximum among all the buffalo breeds found in India and used as an improver breed in the entire
country. The breed has been taken to several European countries for production of Mozzarella cheese. Milk yield is around 1700 kg per lactation with the average fat of 6-7%.

- Nagpuri buffaloes are distributed in Maharashtra. This breed has Light body size and moderately developed udders. Males are good for transport under hot climatic condition and females are good milkers. Low maintenance cost, high feed efficiency and high milk fat content are the advantageous characteristics of this breed. Milk yield is around 1200 kg per lactation with the average fat of 5-6%.

- Nili Ravi buffaloes are distributed in Punjab. Nili Ravi is a medium sized breed with well shaped and capacious udders. The productivity of this breed is also good. Milk yield is around 1800 kg per lactation with the average fat of 5-6%.

- Pandharpuri buffaloes are distributed in Southern Maharashtra and parts of Karnataka. Pandharpuri animals are medium sized but compact body conformation and udder is predominantly of trough shape with squarely placed cylindrical teats. This breed has special characteristics of letting down milk at any place and at any time. Generally, the animals are taken to customer’s house and required amount of milk is milked and then taken to next customer’s house for milking the required milk. Milk let down is not a problem in this breed. This type of behavior has not been recorded in any other breed of buffaloes. Milk yield is around 1500 kg per lactation with the average fat of 7%.

- Surti buffaloes are distributed in Gujarat and adjoining areas of Maharashtra. Surti animals are light and compact body conformation and udder is spacious with medium sized and squarely placed teats. These animals have higher fat percent. The males of Surti animals useful for road transport. Milk yield is around 1400 kg per lactation with the average fat of 8-9%.

- Toda buffaloes are distributed in Tamil Nadu. Animals are very strong and live in hamlet and are known to take fights. The milk production is low ranging from 400-700 kg in average lactation length of 200 days with the average fat of 8%.

The principal buffalo breed in Pakistan is Nili-Ravi, which is the dominant breed in the country while the other two breeds viz., Kundi and Azakheli are also contributing to milk production. The average lactation milk yield of Nili-Ravi buffalo ranges from 1800 to 2400 liters with a lactation length of 260 to 325 days. The original habitat of the Kundi buffalo breed is the irrigated tract of the province of Sindh and is second to the Nili-Ravi breed in milk production. The
average lactation milk yield of Kundi buffalo ranges from 1800 to 2300 liters with
a lactation length of 280 to 320 days. Azakheli is much smaller animal.
It is not clear that the buffalos of Afghanistan are related to which types of
buffalo’s breeds, but according to the geographical situation of Afghanistan this
species are related to the Indian and Pakistani breeds of buffalos. The milk
production capacity of the buffaloes has been reported to be around 1500-1800
litres during 9-10 months of a lactation period. The buffaloes of Bangladesh are
mostly river type with poor milk yield although swamp type exists. The majority
of buffaloes in Sri Lanka are of indigenous type while a substantial number of the
population consists of cross-bred animals of indigenous x Indian origin animals.
During recent times, buffalo is gaining popularity as a dairy animal due to the
inherent characters of milk (with high fat & SNF) they produce more efficiently
than neat cattle under dry farming systems.
Chapter 4

DAIRY ANIMAL PRODUCTION SYSTEMS

In SAARC member countries, the dairy animal production systems vary with the agro-ecological regions and from farm to farm within region mainly because of variation in the level of animal husbandry or degree of dairy animal management interventions applied at a particular location. There are areas where there is very little husbandry management and so minimum human modification of the production environments (zero or low input production system). There are areas where the level of husbandry management is slightly better where some inputs in terms of housing, feeding and animal health activities are being given to dairy animals (medium input production system). There are areas having very intensive management systems where feed, climate, animal diseases and all other factors are controlled or managed by the farmers (high input production system). A common strategy may not be applicable for different countries with different dairy animal production systems. Separate and system specific strategies for different types of milk producers keeping in view the constraints and advantages of every system need to be evolved. As such, knowledge about different production systems is important to design tailored dairy development programmes.

Generally, the dairy animal production systems in SAARC member countries can broadly be classified into three systems based on the level of human interventions.

Low input production system

In this system, several rate-limiting inputs impose continuous and severe pressure on livestock resulting in lower rates of survival or reproduction and overall output. Animals are poorly fed with whatever is available and their nutritional requirements of body growth, maintenance and production are not fulfilled. No arrangements are made to protect the animals from climatic extremes or environmental hazards. Very little or no preventive measures are taken against the onset of infectious or metabolic diseases and the morbidity as well as mortality rates due to prevailing diseases are generally very high. Under this type of production system, the overall production risks are very high mainly because of limited or non-availability of resources and frequently go beyond human management capacity.

Medium input production system

In this system, available resources are moderately managed and modest efforts are made to overcome the undesirable effects of production environments. Under this type of production system, some of the rate-limiting inputs are managed by the
farmers but one or more major out-put limiting factors are not controlled and continue to adversely affect the livestock productivity in a serious fashion. For example, some attention is paid to meet the nutritional requirements of animals in production by providing concentrate rations in order to maintain or improve the level of production. Feeding requirements of young growing animals, non-pregnant heifers and dry females are generally ignored. Low-scale efforts are made to provide separate housing facility to the animals. No investment is made for the procurement of quality vaccines or implementation of a regular program of vaccination of animals, although disease control services provided by the government agencies are availed. Unlike the low-input production system, the farmers operating under the medium-input production system are market-oriented and about 40-60% of the product are sold at prices much lower than consumer’s price mainly because of the involvement of a long chain of middle men in the marketing process.

**High-input production system**

This system uses modern techniques of husbandry management and enhancement of livestock productivity. Under the high-input production system, all rate-limiting inputs to production can be managed and the level of human intervention is maximum. Only the high producing animals are kept which are fed according to their nutritional requirements of body growth, maintenance and production level. They are provided with comfortable and separate housing facilities. Liberal investments are made for the control and treatment of animal diseases. Resultantly, the animals kept under this type of production system express highest survivability; reproductive efficiency and production potential. The high input production system is based upon purely commercial livestock farming set-up so the production risks are kept minimum. The solitary constraint of output is, therefore, the inability of farm manager to make appropriate and timely decisions.

Almost all the dairy production systems in the SAARC member countries are covered under these above-cited 3 classifications. However, there are some country specific systems/dairy animal management depending upon the agro-ecology, availability of inputs and the tradition, the overview of which is given below.

**Afghanistan**

Livestock production in Afghanistan is generally a low-investment activity aimed primarily at meeting subsistence needs, with, if possible, a surplus to sell. Even the smallest and poorest farmers keep at least one cow to provide their subsistence requirements for dairy products, but many farmers have more than one cow, and this is a common pattern all over the country. Compared to small ruminants, cattle have important benefits for milk production, especially for small farmers because i) cattle are easier to manage than sheep or goats ii) cattle have a longer lactation
length and less seasonality of production and iii) they remain in the villages
during the whole year, which allow the supply of fresh milk and dairy products to
the whole family. In Afghanistan, there are three systems within which dairy
animals are managed viz. sedentary system, settled transhumance system and
nomadic pastoral system.

Sedentary systems are practiced by farmers whose main activity is producing field
and fruit crops (often a combination of both), who also rare some cattle, sheep and
goats as well as poultry as an adjunct to these activities. Common grazing or
rangeland is used for grazing or obtaining fodder for animals. Animals are large
and maintained on a balance of grazing, fodder and crop residues along with little
grain supplementation.

Settled transhumance systems are practiced by farmers whose primary activity is
raising livestock, but who also cultivate grain and fodder crops. These
communities move their livestock between different seasonal settlements, winter
and summer, together with some of the community.

Nomadic pastoral systems are practiced by mobile pastoralists or kuchi whose
main livelihood and lifestyle is based on a tented life, raising livestock for the
production of meat, milk products and wool. They move with their flocks and
herds as the seasons and grazing dictate, along well-defined lines of migration.
The fodder and grain required for feeding animals procured from the settled
farming communities near which they camp.

**Bangladesh**

In Bangladesh, smallholder dairying predominate the dairy production system,
which is generally integrated with crop production activities. This system can be
classified into i) Rural, ii) Peri-urban and iii) Structured market.

Rural dairying is generally subsistence based and can be classified under low
input production system. Most of the farmers under this system keep 1-3 dairy
cattle irrespective of the land holding capacity. Both local cows and crossbreds
are reared but the local cows dominate the system. The rural dairy farmers feed
rice straw, cut-and-carry green grass and average concentrate mixture comprising
mainly of rice bran, wheat bran, oil cake and broken rice. Irrespective of farm
category, the dairy animals are fed with rice straw, cut-and-carry grass and little
concentrate.

Peri-urban dairying is practiced on the periphery of cities, towns and other urban
areas due to high demand of milk in urban and peri-urban areas. The average
cattle head per farm may be from 3 to 10, with more preference for crossbred
cattle. The peri-urban dairy farmers fed their dairy animals with rice straw, green
grass and concentrate mixtures containing rice or wheat bran, oil cake and broken
rice. The peri-urban farmers do not keep their animals in open rearing systems; majority of the animals are kept under stall cum open or under stall-fed conditions.

The dairies under the structured milk marketing area of the cooperatives are termed as structured market dairies. Small, medium and large farmers engage in dairy activities in these areas. Both local and crossbred cows are reared under these areas, however unlike rural dairying, the preference/population of crossbred are high. The average head count/farmer may range from 2-8 milking cows or more. The concentrate mixture contains as usually rice or wheat bran, oil cake and broken rice. In this system, the dairy animals are also fed with rice straw, cut-and-carry grass and moderate quantity of concentrates. Animals are fed in stalls, stall cum open or open feeding system.

**Bhutan**

The traditional farming system in Bhutan involves integration of crop production, grazing animals and forest areas into a mutually supportive system. Within this multi-composite farming system, dairy animals play a critical role by providing draught power, manure and livestock products for sale or home consumption. There are three distinct types of large ruminant production systems in Bhutan viz. transhumance system, migratory system and sedentary rearing system.

The transhumant system (mostly yaks) is limited to the alpine-cool temperate areas. This system is associated with nomadic herders in the alpine-cool temperate areas who keep yaks and sheep as their sole source of livelihood.

The migratory cattle system is practiced in the temperate-sub-tropical area. The migration takes place, depending on the number of pastures owned by the herders and their location. This production system is also influenced by the in-born nature of the yaks which keep on moving in response to temperature changes.

These two systems take advantage of the variations in climate and vegetation as herders migrate with their animals according to the seasons.

The third is the sedentary livestock rearing system in semi-urban and other rural settlement areas, the characteristics of which is almost similar to other countries and discussed earlier.

**India**

In India, the dairy production system is complex but can broadly be divided into four categories viz. pastoral system, semi intensive or crop-livestock production system, peri-urban dairying and intensive or industrial production system.

The pastoral system and crop-livestock production system aims at providing low input and obtaining medium output while the peri-urban dairying aims at medium input and medium output and the industrial production system is characterized by
high input and high output. An interesting feature of the Indian dairy farming is the production system where the dairy animals are largely fed on crop residues and high producing animals are supplemented with concentrate feed.

In pastoral system, big herds of cattle are maintained and kept on migration for more than six months in a year. In this system the animals migrate due to paucity of feed and fodder in their native habitat. Therefore, the herds migrate in search of feed and fodder during lean months. The migratory herds consist of cows, bulls and calves. Sometimes calving also takes place during the migration. In such breeds, income mainly comes from sale of milk, penning charges (keeping the herd in agricultural fields for soil enrichment) and sale of bullocks.

In semi intensive or crop-livestock production system, few cows, bullocks and followers are kept by the farmers. In this production system the productivity of the animals is low to medium and kept on grazing with the small amount of stall feeding with green fodder, concentrate, crop residue or kitchen waste. The majority of indigenous cattle or non-descript animals are generally kept under this system. In this production system the natural mating occurs during the grazing but some of the animals are also inseminated with good quality bull semen available in nearby AI centres. Some of states of India are extending the facility of AI with good milch, dual purpose or draft breeds of Indian origin. Under this production system the milk is partly consumed by the farmer’s family and partly sold to milk societies or middle men. The male progeny born is converted into bullock and sold on good prices from the farmers in locally available markets/cattle fairs. The farmers also utilize the dung as fuel or manure.

Peri-urban and urban dairy production system is becoming an important supplier of milk products to urban centers, where the demand for milk and milk products is remarkably high. As a result of this, peri-urban and urban dairying is being intensified through the use of cross breed dairy cows, purchased and conserved feed and stall-feeding. These production systems are favored due to the proximity of the production sites to centers of high fresh milk demand, easy access to agro-industrial by products, veterinary services and supplies. Nonetheless, the existing dairy farming practices in peri-urban and urban areas of the country is largely characterized by modern dairy farming practices covering a range of intensive management practices and zero grazing. This production system also involves the use of exotic crossbreed genotypes that give high yield as compared to the traditional dairy farms.

In recent years, many large sized dairy farms have been emerged in the countries who are mainly concentrating the husbandry of crossbred/ exotic cattle under high-input high-output production system. In this production system high milk producing animals are kept on stall feeding and good facilities are provided to them for breeding, health and other general management. In this production
system AI is a tool for the breeding of females and bulls are generally not kept in the herds. The marketing of milk is also ensured to public and private entrepreneurs and proper recording system may also be seen at such farms.

**Nepal**

Milk production in Nepal broadly can be classified into two systems are traditional subsistence milk production system and market linked commercial/semi commercial milk production system.

Under traditional subsistence production system, majority of the dairy animals are of indigenous origin, are kept in low input and mostly under grazing management with rare uses of external inputs. Under this system animals are kept for milk and milk products mainly for household consumption. Surplus milk if any is sold to village tea shop if the opportunity for this exists in the village.

In smallholder commercial/semi commercial system, the farmers manage their herds in order to maintain a steady supply of milk. The number of milch animals reared in a smallholder system has a certain ceiling depending upon the size of landholding, the availability of feed, and human labour. In the major dairy pocket areas of Nepal, majority of the dairy farmers are smallholders. Although both buffaloes and cattle co-exist in a single farm together, the use of buffalo is becoming popular among small farmers because of their adaptability to local feed resources, high milk fat content, and salvage value in the hills. Recent times witness growth of peri-urban dairies in areas where there is good road link and good market potential for the milk and products in adjoining city centre. The animals in this system depend on straw and concentrates, whereas there is a practice of cultivating forage grass depending on availability of land in peri urban areas. Green grasses from fallow land and roadside and from fodder tree is also available in the peri urban areas.

**Pakistan**

The dairy animal production system is almost similar to that of India however based on the driving force it can be classified into rural smallholder subsistence production system, rural market oriented subsistence production system, rural commercial buffalo production system and peri-urban milk production system.

In rural smallholder subsistence production system, an average production unit consists of three buffaloes including one or two adult females. About 50-60% of the feed requirements are met from grazing at no cost other than labor for guarding the animals during grazing. The remaining 40-50% of the feed requirements is met through feeding of wheat straw and some green fodder. Concentrates are seldom purchased. The members of farmer’s family consume most of the milk produced.
Rural market-oriented smallholder production system is practiced by those rural small farmers who have access to the nearby markets of livestock and their products. Under this type of milk production system, an average production unit consists of about 5-7 buffaloes. This herd is generally composed of about 3-4 adult buffaloes and one or two heifers. One or two male calves are sometimes kept but buffalo bulls are rare. The lactating buffaloes are generally stall fed with available green fodder, straws and concentrates. The dry buffaloes, heifers and male calves are almost exclusively grazed on wasteland or crop stubbles. More than 50% of the milk produced by the farmers is sold either directly or through middlemen.

About one fourth of the buffalo population is reared under rural commercial buffalo production system. A typical rural buffalo farm running on commercial basis consists of more than 30 buffaloes of which 60% are adult females. Approximately, 40% of these adult females are in milk during most parts of the year. These production units usually have the provision of animal sheds. Fodder crops provide more than 50% of the feed whereas straws provide a further 35% of the feed requirements. Lactating buffaloes receive maximum attention in terms of feeding management and disease control. The dry animals are however, fed on cheap and low quality feed ingredients. Grazing is sometimes available to the animals.

Peri-urban commercial milk production system started developing in Pakistan parallel to the emergence of rural commercial milk production system. These developments took place in response to growing urban demand for milk. Peri-urban milk production units can be divided into large and small units. The large production units are located around major cities whereas the smaller units are established in peri-urban areas of smaller towns and villages. The large peri-urban units have herds ranging from 20 to 50 heads, almost all of which are adult females and more than 95% are in production. Selected third or fourth lactation cows, with calf at foot, are kept over the lactation period of 250 to 300 days. The calves are generally slaughtered after first week. Most dry animals are sold for slaughter but a minority that gets pregnant earlier are kept or returned to rural areas until again ready to calve. Feeding varies with feed availability but will usually include wheat straw, chopped green fodder and concentrate rations, generally home mixed from wheat bran, cotton seed cake and rice polishing or crushed wheat etc.

**Sri Lanka**

The cattle and buffalo production systems can be classified by the breeds utilized and the husbandry practiced, which in turn are closely related to the agro-ecology and climate. These can be summarized for four major agro-climatic/land-use zones: up- and mid-country; the coconut triangle; the wet lowland; and, the dry lowland (Ibrabim et al., 1999).
The Up-country or hill country zone lies above 1200 meters msl and is characterized by tea plantations and dairy production from cattle kept in two systems, the estate- and village-based systems. In the estate-based system many of the employees in the tea estates rear dairy cattle, generally the European breeds, Ayrshire, Friesian and Jersey, and their crosses. In this estate-based system, the dairy farmers own no land and are dependent upon weeds from the estate land and fodder gathered from near waterways and other communal and public areas. Manure is often sold. In the village-based system, the majority of smallholders are crop-livestock farmers, growing vegetables and paddy. Manure is a major product from their cattle, with milk often a secondary source of income.

In the mid-country, the European dairy breed crosses, are an increasing proportion of the smallholder cattle herd, but there are many crosses with Indian breeds and milk yields are correspondingly lower.

In the Coconut triangle and the wet lowlands cattle and buffalo form an integral part of the farming systems, helping in weed control and providing manure in the coconut lands. Buffaloes are used principally for draft purposes in paddy cultivation and are kept in almost all the rice growing areas. Some farmers rear dairy buffaloes, pure Indian breeds or their crosses managed under an intensive or semintensive system. The buffalo milk is generally converted to curd for which there is high demand locally. In both zones cattle and buffalo graze on the fallow paddy fields, as well as on the natural pastures under the coconut plantations and in non-cultivated areas, including common properties.

In the Dry lowland zone cattle are predominantly indigenous Zebu, although Sahiwal crossbred cattle, and improved buffalo in the eastern dry zone, are becoming more common. These cattle and buffalo form an important capital asset (an inflation-proof insurance fund) for the peasant farmers, and where there is the possibility to sell milk, it is becoming an important source of income. Many herds are grazed on common lands and in the farmer’s or neighbor’s fallow paddy fields, and brought to the homestead at night to avoid theft and damage to crops. The feeding of rice straw is common; generally concentrates are not fed. Herd sizes average 10-25 with some of more than 100 animals.

**Issues related to management of animals in peri-urban system**

Since recent days witness mushroom growth of peri-urban dairies, some of the issues related to this type of production system are discussed here. Generally, the productivity of the animals maintained by the peri-urban dairy farmers is higher than those maintained by rural farmers. The dairy animal management efficiency is also found to be higher in the peri-urban/urban dairying compared to rural dairying; however there are some issues that affect the animal welfare.

- Since peri-urban/urban dairying involves large herd, the managers and the labours are oriented towards commercial angle rather than animal welfare aspects.
• Unlike crop-livestock or commercial system where animals are reared under loose housing system or allowed to freely roam for some part of the day, in the peri-urban/urban dairying animals are always stall fed and tied.

• A majority of the peri-urban dairies do not follow standard space requirements of the animals and the animals are reared in congested sheds which at times do not have proper ventilation.

• The calves are generally weaned to save the milk consumed by the calves and this leads to increased calf mortality.

• The quality of drinking water used at the peri-urban dairy farms may affect the productivity, fertility and milk quality of animals. The heavy metals and toxic materials present in the water supply network need appropriate monitoring to assess its fitness for dairy animals’ use.

• Waste management in majority of these dairies is far from the ideal. The organic and inorganic wastes are either channelized to reach canals or being left in open area, which leads to pollution of environment including ground water.

• Intensive livestock production in peri-urban areas, if not carried out properly, may pose new threats to public and environment with the consequences of emerging zoonotic diseases since intensified and poorly guarded human-animal interface establish common route of disease transmission.

---

**Pastoral system**

• Herds of livestock are maintained and kept on migration for more than six months in a year due to paucity of feed and fodder in their native habitat.

• Income mainly from sale of milk, penning charges (keeping the herd in agricultural fields for soil enrichment) and sale of animals.
**Crop-livestock system**

- Few heads of livestock along with their followers are reared. Majority of indigenous or non-descript animals are reared under this system.

- Animals are kept mainly on grazing in addition to small amount of stall feeding with green fodder, concentrate, crop residue or kitchen waste. The dung produced is used as fuel and manure for crops.

---

**Intensive system**

- The commercial or intensive livestock production system is gaining momentum.

- High producing animals are kept on stall feeding and good facilities are provided to them for breeding, health and management.

- Performance recording and proper marketing channels to ensure high income.
Types of milk producers in SAARC member countries

Generally, the dairy farmers of SAARC member countries can be classified into four categories. Although the mode of production varies, all these groups are involved in contributing positively to the production of milk for human consumption. The following are the broad categories of dairy farmers.

**Dairy animal dependent population:** Pastoralists are classified in this category. Pastoralists rely on their animals to provide food, income, transport and fuel. By supporting their own population and generating surplus for sale, these societies contribute to the country’s supply of food as well as their own food access. The livelihoods of the mobile pastoralists are characterized by a critical dependence on a vulnerable natural resource base and extreme marginal conditions, which hamper their access to roads, markets and services. To improve the livestock performance in this system, the common property resources need to be strengthened.

**Small scale mixed farming population:** Small-scale mixed farms remain enormously important because of the large number of rural households they feed and provide with livelihoods. They depend greatly upon animals for their livelihoods. They are often involved in small-scale farming systems where dairy

### Characteristics of the systems

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Pastoral</th>
<th>Crop-livestock</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed</td>
<td>ND/Indigenous</td>
<td>ND/Indigenous/CB</td>
<td>CB/Exotic</td>
</tr>
<tr>
<td>Replacement stocks</td>
<td>Own</td>
<td>Farm born</td>
<td>Farm born/outside</td>
</tr>
<tr>
<td>Concentrate</td>
<td>Nil</td>
<td>Household/on farm generated</td>
<td>External source</td>
</tr>
<tr>
<td>Fodder</td>
<td>Nomadic/CPRs</td>
<td>On-farm</td>
<td>On farm/External source</td>
</tr>
<tr>
<td>Dependency on external paid inputs</td>
<td>Nil</td>
<td>Almost nil</td>
<td>Highly dependent</td>
</tr>
<tr>
<td>Labour</td>
<td>Own</td>
<td>Own</td>
<td>Fully hired</td>
</tr>
<tr>
<td>Livestock wastes</td>
<td>Agricultural fields/CPRs</td>
<td>Crop-production</td>
<td>Disposed off</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Yes</td>
<td>Yes</td>
<td>Dependency on external inputs is high</td>
</tr>
</tbody>
</table>
animals play a central role as a source of food, income and critical inputs for agricultural production (such as draught power and manure). This system of production is common across the region and policies to protect their interest and to enhance the productivity are needed to be in place.

Peri-urban milk producers: They are often either the better-off or the poorest groups or households from the previous two classes, who live in the fringes of urban areas in order to better access labour, income and services to cope with their limited access to productive resources. Nowadays this type of production system is expanding to several areas and it need to have proper measures and policies to ensure quality of the output as well as the health of dairy animals besides the environment management.

Commercial or large scale producers: The dairy farming scenario is witnessing a gradual transformation during last one/two decade from traditional production system to commercial production system. The commercial production system consists of keeping high producing crossbred cows and/or buffaloes starting from about 10-20 in number to 1000 or more and managed under better housing, feeding, breeding and healthcare. Many of these farms have been established or are in the process of being established by educated youth both rural and urban and have been financed by banks. The corporate firms have also shown keen interest in investing in dairy farming and some corporate owned dairy farms are already in existence and many more are in the process of being established. Several of these which were hitherto engaged in milk procurement and processing are also venturing into milk production in view of the rise in demand and issues of quality of milk procured from outside. Many of these farms with fairly good number of animals ranging from 100 to 500 are making use of modern production technology including mechanical milking; fodder harvesting its preservation and feeding, waste disposal etc.
Chapter 5

MILK PRODUCTION IN SAARC MEMBER COUNTRIES

In the last three decades, world milk production has increased by more than 50 percent, from 482 million tons in 1982 to 754 million tons in 2012. Asia is accounted for most of the increase, with output in India, the world's largest milk producing country, by producing 132.4 million tons in 2012-13. The trend in milk production in the world is given in figure 11. Developed countries house two-third of world dairy herd but contribute to one-third of the world milk production. The most significant milk producers in developed countries are the EU, the United States (Figure 12). In developing countries India and China rank first and second, respectively in milk production. The growth rate of milk production in India, China, Pakistan, Argentina and Brazil shows future prospects. The world average level of consumption of milk and milk products is 103.6 kg/capita/year and it is expected to increase in both developing and developed countries. The milk production/cow/year in developed countries like USA, Denmark, Sweden, Finland, The Netherlands etc are above 7500 kg whereas in SAARC member countries the average milk production/cow/year is less than 1500 kg indicating enough scope to improve the productivity (Figure 13). The dairy sector in SAARC member countries has emerged as an important source of livelihood for a vast majority of the rural population, especially the poor. Besides being a source of supplementary income and nutrition, the sector also provides draft power, fuel and organic manure. More importantly, the sector contributes significantly to the national economies of these countries; for example, milk is the single largest contributor (in the agricultural sector) to the national GDPs of India and Pakistan. However, there lies a huge potential that needs to be harnessed. Although this region contributes a considerable portion of milk to the world’s milk pool, the productivity of animal remains low. A critical analysis of the milk production scenario, identification and prioritization of most suitable animals/breeds and strategizing dairy production system is the need of the hour. In this line, the milk production scenario in SAARC member countries and the contribution of different animals for the total milk production in the region along with productivity gaps are analyzed here.

In 2011 the world milk production stood at 730 million tons, of which the SAARC member countries contributed 165.4 million tons (22.66%). The contribution of different SAARC member countries to the total milk production is
given in figure 14. Of the total milk produced in the region, 42.75% of milk was contributed by cattle while 52.26% was from buffaloes. Goat and camel contributed to 4.86% and sheep milk (mainly in Afghanistan) contributed to 0.12% (Figure 15). About three-fourth of the milk produced in the region is contributed by India alone. Next major contributor for milk production is Pakistan, which produced about 22.14% of the total milk produced in the region. All the other countries in the region contributed to the remaining part of the total milk produced. The AGR in total milk production in SAARC member countries between 2006 and 2011 was 4.11%. The milk production was 132.64 million tons, which increased to 165.40 million tons in 2011 with the AGR of 3.89%. The trend in total milk production in the region are given in figure 16.

Milk production trend in different SAARC member countries

In 2006, the total milk production in Afghanistan was 1.62 million tons, which increased to 1.72 million in 2011. The AGR in milk production between this period was 1.04%. Bangladesh produced 2.69 million tons of milk during 2006, which increased to 3.33 million in 2011 with the annual growth rate of 3.94% during this period and finally milk production reaches around 5 million tons in 2013. The milk production in Bhutan was 0.042 million tons in 2006 and the total milk production decreased to 0.039 million tons in 2011 with AGR of -1.41%. India witnessed a positive AGR of 4.26% in milk production from 2006 to 2011. The milk production increased to 121.8 million tons in 2011 from 97.0 million tons in 2006. Nepal also showed a positive trend in milk production. The AGR of milk production during the period from 2006 to 2011 was 3.02%. In Nepal, the total milk production increased from 1.38 million tons in 2006 to 1.63 million tons in 2011. Pakistan produced 31.18 million tons in 2006, which increased to 36.62 million tons in 2011. The AGR in milk production between this period was 2.91%. Sri Lanka had a high growth rate in milk production from the period 2006-2011 with the AGR of 5.23%. The total milk production in the country was 0.20 million tons in 2006, which increased to 0.26 million tons in 2011. Overall, all the country except Bhutan had a positive growth in milk production. The trend in milk production in the individual countries of SAARC region from 2006 to 2011 is given in figure 17.
Figure 11: World milk production in million tons

Source: FAO

Figure 12: Top 10 milk producing countries in the world
Figure 13: Average individual animal milk production (kg/year) in different countries

Figure 14: Contribution of different SAARC member countries to total milk production in the region in 2012 (FAO)
Figure 15: Contribution of different animals to total milk produced in the region

Figure 16: Trend in total milk production in SAARC member countries
Figure 17: Trend in milk production in individual SAARC member countries
Contribution of different animals to milk production in individual SAARC member countries

For assessing the contribution of different dairy animals to the total milk production in different SAARC member countries, the 2011 data on milk production were used. In Afghanistan, among different dairy animals, cattle contributed to 81% of the total milk produced in the country while the goats contributed to 12%. In Bangladesh, the cattle are the major contributors to the total milk production while buffalo and goat contributes a small proportion. The contribution of sheep milk was 7%. Cattle including yak are the major players in milk production in Bhutan. In India, buffalos and cattle are the major players in milk production. Although buffalo population is around half of the population of cattle, they contribute 51.09% of the total milk produced in the country. The milk from cattle accounted to 45.17% of the total milk produced in 2011 while other minor players include goats and camels, whose contribution was to the tune of 3.74%. In Nepal, buffaloes are the significant contributors of the milk production in the country. They contribute to 68% of the total milk produced in the country. While 27% of the milk in Nepal is produced by cattle, the goats contributed to 5% of the total milk production. In Pakistan, buffaloes are the major contributors to the country’s milk production; they contributed 63% of the total milk produced in the country during 2011. While 35% of the milk in Pakistan is produced by cattle, the goats contributed to 2% of the total milk production. In Sri Lanka, cattle and buffalo are the dairy animals contributing to the milk production in the country. Cow milk accounted to 79% of the total milk produced in the country in 2011 while the remaining 21% was from buffaloes. The contributions of different animals to the total milk production in individual SAARC member countries are given in figure 18.

Performance appraisal on individual animal milk productivity

The data on per cow milk productivity, as indicated by FAO for the year 2011, in component countries is used to analyze and compare the individual animal productivity in SAARC member countries as a whole. The average milk production per cow during 2011 was 627.86 kg/year, while the average milk production per buffalo stood at 1257.96 kg/year. On an average a goat in SAARC member countries produced 83.45 kg/year in 2011. The individual animal milk productivity in SAARC member countries are given in figure 19. Among the different member countries, the milk productivity per cow per year was higher in
Pakistan followed by India. Lowest milk productivity per cow per year was observed in Bangladesh. The milk productivity per buffalo per year was also higher in Pakistan followed by India. There are high variations in per animal milk productivity among the SAARC member countries.

**Average milk production per cow**

Among the SAARC member countries, the average milk production per cow was highest in Pakistan (1229.96 kg/cow/year) followed by India (1191.54 kg/cow/year) in 2011. Sri Lanka stood at third position among the SAARC member countries regarding the average milk production per cow (683.26 kg/cow/year). On an average, a cow in Nepal produced 459.07 kg/cow/year while the corresponding figure for Afghanistan was 369.21 kg/cow/year. The average milk productivity of cows in Bhutan (257 kg/cow/year) and Bangladesh (204.98 kg/cow/year) are towards lower side.

**Average milk production per buffalo**

The average milk production per buffalo was highest in Pakistan (1934.96 kg/buffalo/year) followed by India (1700.78 kg/buffalo/year) in 2011. Nepal stood at third position among the SAARC member countries regarding the average milk production per buffalo (858.85 kg/buffalo/year). The average milk production per buffalo was 537.35 kg/buffalo/year in Sri Lanka.

**Average milk production per goat**

India stands first regarding the average milk production per goat with the productivity of 150.16 kg/goat/year followed by Pakistan (140.56 kg/goat/year). Bangladesh stood at third position among the SAARC member countries regarding the average milk production per goat (80 kg/goat/year). In other countries, the average milk production per goat was around 50 kg/goat/year or less.
Figure 18: Contributions of different animals to the total milk production in individual SAARCC member countries
Trends in milk productivity per individual animal
The individual animal’s milk productivity was analyzed from 1961 to 2011 to understand the trend. The trends of individual animal’s milk productivity (cow, buffalo and goat) are given in figure 20.

Afghanistan
The individual cow milk productivity showed fluctuations over the period. The individual cow milk productivity was 500 kg/year in 1961, which decreased to 475 kg/year in 1971 then increased to reach all the time average of 545.46 kg/year in 1991. However, after that the individual cow milk productivity started decreasing and reached 369.21 kg/year in 2011. The individual animal milk productivity remained same across different periods from 1961 to 2011 in sheep and camel. The individual animal milk productivity in goats increased over the period to reach 50 kg/year in 2011 from 41.97 kg/year in 1961.

Bangladesh
The individual cow milk productivity was 250 kg/year in 1961, which showed a decreasing trend thereafter to reach 204.97 kg/year in 2011. The average milk productivity of individual buffaloes remained almost constant (around 400 kg/annum) during the period from 1961 to 2011. Similarly, the average milk productivity of goats also remained almost constant (80 kg/year) over the period.
India
There has been a substantial increment in the individual cow milk productivity in India. The individual cow milk productivity was 423.53 kg/year in 1961, which hereafter increased continuously to reach 1191.54 kg/year in 2011. Similarly the average milk productivity of individual buffaloes also showed a significant increase during the period (from 889.59 kg/year in 1961 to 1700.78 kg/year in 2011). The individual animal milk productivity in goats increased over the period to reach 150.16 kg/year in 2011 from 100 kg/year in 1961.

Nepal
The individual cow milk productivity remained similar from 1961 to 1981 (around 325 kg/annum), which hereafter increased continuously to reach 459.06 kg/year in 2011. Unlike cows, which witnessed increase in productivity, the average milk productivity of individual buffaloes decreased from 1708.54 kg/year in 1961 to 858.85 kg/year in 2011. The average milk productivity of goats remained similar (50 kg/annum) over the period.

Pakistan
Like India, Pakistan also witnessed almost a continuous increase in individual milk productivity of cows. The individual cow milk productivity was 887.37 kg/year in 1961, which showed an increasing trend to reach 1229.96 kg/year in 2011. Similarly the average milk productivity of individual buffaloes also showed an increasing trend during the period (from 1637.74 kg/year in 1961 to 1934.84 kg/year in 2011). The individual animal milk productivity in goats increased over the period to reach 140.56 kg/year in 2011 from 90.74 kg/year in 1961.

Sri Lanka
The individual cow milk productivity in Sri Lanka showed a fluctuating trend with an increasing trend from 1961 (279.25 kg/annum) to 1981 (728.61 kg/annum), which decreased to 584.43 kg/year in 1991 and thereafter increased to reach 683.26 kg/year in 2011. Exactly similar trend was observed in individual buffalo milk productivity also. The average milk productivity of individual buffaloes was 325.12 kg/year in 1961, which increased to 537.24 kg/year in 2011. The average milk productivity of goats remained similar (30 kg/annum) over the period.

Productivity yield gap analysis
Yield gap has been examined at country level by comparing the milk productivity with respect to all-SAARC member countries average, country with top-productivity among member countries and a country with top-productivity in the world. The yield gaps analysis for milk production in cows and buffaloes are given in table 4 and 5, respectively. When compared with all- SAARC member
countries average productivity of cows, it was observed that except India, Pakistan and Sri Lanka, all the other countries had yield gaps ranging from 67.36% to 26.91%. The yield gap was very high in Bangladesh followed by Bhutan, Afghanistan and Nepal. When the average milk productivity of individual cows from different countries was compared with country with top-productivity among SAARC member countries (Pakistan), it was observed that excepting India, the yield gaps of all other countries were high. The yield gap was highest in Bangladesh (around 83%) followed by Bhutan, Afghanistan, Nepal and Sri Lanka. When the average milk productivity of individual cows from different countries was compared with Israel (the average milk productivity of a cow in Israel is 11393 kg/year), it was observed that the average milk productivity of individual cows was less than 10% of Israel’s productivity in most of the SAARC member countries.

Table 4: Yield gap analysis for milk production in cows (2011)

<table>
<thead>
<tr>
<th>Country</th>
<th>Yield gap (%) with SAARC Average</th>
<th>Yield gap (%) with Pakistan</th>
<th>Yield gap (%) with Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>41.21</td>
<td>69.98</td>
<td>96.76</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>67.36</td>
<td>83.34</td>
<td>98.20</td>
</tr>
<tr>
<td>Bhutan</td>
<td>59.08</td>
<td>79.11</td>
<td>97.74</td>
</tr>
<tr>
<td>India</td>
<td>-89.74</td>
<td>3.13</td>
<td>89.54</td>
</tr>
<tr>
<td>Nepal</td>
<td>26.91</td>
<td>62.68</td>
<td>95.97</td>
</tr>
<tr>
<td>Pakistan</td>
<td>-95.86</td>
<td>---</td>
<td>89.20</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>-8.76</td>
<td>44.47</td>
<td>94.01</td>
</tr>
</tbody>
</table>

In buffaloes, when compared with all SAARC member countries average individual animal productivity, it was observed that the yield gap was high in Bangladesh followed by Sri Lanka and Nepal. The all member countries average productivity was 35% less than the average of India and 54% less that average of Pakistan. When compared with Pakistan, the yield gaps in all the other countries having buffaloes ranged from 12% in India to 79% in Bangladesh.
Table 5: Yield gap analysis for milk production in buffaloes (2011)

<table>
<thead>
<tr>
<th>Country</th>
<th>Yield gap (%) with SAARC Average</th>
<th>Yield gap (%) with Pakistan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>68.20</td>
<td>79.33</td>
</tr>
<tr>
<td>India</td>
<td>-35.21</td>
<td>12.09</td>
</tr>
<tr>
<td>Nepal</td>
<td>31.72</td>
<td>55.61</td>
</tr>
<tr>
<td>Pakistan</td>
<td>-53.82</td>
<td>---</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>57.31</td>
<td>72.25</td>
</tr>
</tbody>
</table>

All the above analyses indicate a clear yield gap in individual animal’s milk productivity, which is generally attributed to the poor genetic potential of huge non-descript population. However considering the potential existing within the region, we need to prioritize the dairy animals in respective countries and evolve suitable strategies for improving productivity through exchange of germplasm, knowledge and other possible resources among the member countries of SAARC. The details are discussed in the following sections.
Figure 20: Trends of individual animal’s milk productivity in SAARC member countries
Chapter 6

SITUATION ANALYSIS OF INPUTS FOR DAIRYING

Dairy animal’s productivity depends on various input activities of a dairy production system. Dairy production starts with preparation of accurate dairy plans, sourcing and making availability of appropriate inputs in terms of resources like land, animal, feed and fodder, disease diagnostics, preventive and control measures, manpower, knowledge and skills etc. Availability of inputs at appropriate time is essential for improving the productivity of the system. Execution of the dairy plan is followed by monitoring of the production system and periodical interventions in terms of various input activities for further improvement of the existing dairy production systems. Several countries have adapted crossbreeding for improvement of milk production, however if the genotype is not matched with the production environment it will not yield desirable results. Thus, it is imperative to analyze the status of existing inputs for dairying and to develop strategies to fulfill the requirements of essential inputs that could otherwise impede the dairy development in the region. The situation of inputs for dairy production in SAARC member countries are discussed herewith.

Feed and fodder resources

As a result of breed improvement, the dairy animal has changed significantly over the past decades with a remarkable increase in milk production/lactation in some of the countries. Nutritional management of these high producing dairy cows, especially during periods of high levels of stress, is an important and challenging task to maintain and improve animal health and reproduction. Cost effective balanced ration formulation and its use is the most important intervention after breed selection to improve the productivity of animals. Rations that optimize milk yield should be developed and used with focused approach toward forage quality, feeding management and nutrition.

Afghanistan

By-products of the staple crops (wheat, maize, rice and pulses) make up the bulk of the winter feed in the form of straw and stover for cattle. If available, and only when needed, some better quality Lucerne hay (supplemented with milled barley or maize grain and pulses) is used. The crops and the cropping systems practiced have often been developed over many generations to fit the particular environmental circumstances of the location. Crop cultivation in different areas are determined by the environment and whatever the crop cultivated they make up
the basis of livestock feed and fodder. Where a village has access to grazing areas this is the common right of all livestock-owning members of that community. Stubble and crop residues are also generally open to all in the community for the period between the clearing of the harvest and the subsequent cultivation.

In case of settled livestock owners, as livestock ownership and management systems are dependent on being able to move between different seasonal grazing areas over long distances, between their summer pastures and their winter camps.

**Bangladesh**

Dairying in Bangladesh mostly depends on crop residues, by-products and cut-and-carry green fodder. There are no permanent pastures or extensive grazing lands except in very few areas. In smallholder production system, natural grasses, weeds from cropped areas, bushes and shrubs from private land, fallow lands, cultivable waste land and road side grasses constitute the sources of green fodder along with tethered grazing on community lands and road sides (Md Abdur Razzaque Mia, 2013). Cultivated perennial fodder grass Napier, seasonal crops like cowpea and other pulses are mainly grown on cultivated land and crop borders and in the paddy field after paddy harvest or as relay crops in some pockets of the country. The amount of green forage available for ruminant feeding in Bangladesh is about 2.29 million MT per annum. Crop residues commonly available are rice straws, wheat straws, maize, stovers, sugar cane tops and other crop thrash. The by-products are wheat bran, rice polish, pulse husks and oil cakes. About 2.9 million MT by-products are produced in the country but only 0.97 million ton is available to feed cattle against a requirement of 2.8 million MT to produce 5.6 million MT milk (Pal and Siddiky, 2011).

Milling by-products and small quantities of grains (broken rice, maize and wheat) constitute the grains for concentrate mixture for feeding cattle. The use of concentrate feed is usually restricted mostly to milking cows and its extent depends on the commercial viability of dairy farming and access to milk marketing. Calves, growing stock and dry animals normally do not receive any concentrate feed and survive mostly on dry fodder and green forage and tethered grazing. Concentrate feeds are fed mostly to milking animals. Almost all farmers make their own feed mixes. Concentrate feed items are mostly imported. There are private small feed plants, but feeding of compounded feed to cattle is not very popular. As such, a big gap exists in Bangladesh between the requirement and production of concentrate feeds for cattle.

**Bhutan**

The use of feed resources in the mixed farming system prevalent among the farmers in Bhutan is influenced by the cropping system, agro-ecological conditions, and the type of animal reared on farm. The most common feed
resources available to farmers are forest, cultivated fodder, and crop residues. It has been reported that about 20% of fodder requirement for the cattle population is being met out by grazing fodder shrubs in the forest. In temperate region, improved pastures consisting of a mixture of white clover, tall fescue, cocksfoot, and Italian rye grass are important source of cattle. Improved fodder is mainly fed to milking cows, bulls, and growing cattle. Excess grass is cut and made into hay for winter feeding in these areas. In subtropical areas, green leaf desmodium, molasses grass, ruzi grass, and stylo are grown for feeding cattle. At lower altitudes, maize is cultivated and fed to draught animals during rice transplantation. Wheat is cultivated in a range of production systems including the rice based systems after the rice harvest. Oats, by virtue of higher biomass production, have partly replaced wheat as a winter fodder in the rice-growing areas. Fodder trees are important feed resources in many parts of Bhutan especially during the dry winter season. Tree fodders are also being cut and carry to households for feeding dairy cattle.

Crop and agro-industrial residues also account for a considerable portion of the feed requirement of cattle. Maize, wheat, and buckwheat straw are important winter feeds in the areas where they are grown, while rice straw is used by almost all farmers in rice growing areas. Other important crop residues include inferior and broken grain, husks and chaff (by-products of milling). Residues from chang (local brew) production also provide an important feed for dairy cattle.

Commercial concentrate feed mixtures are supplied by the only private feed manufacturing plant with most of the ingredients being imported from India. Concentrate feed is generally unaffordable for most traditional and transitional farmers. These farmers feed their cattle with concentrate mixture consisting of mustard oil cake, maize flour, chang residue, salt, kitchen waste while progressive farmers depend on concentrate feed mixture.

**India**

It has been tradition in India to have community pasture land in each village, which has been an important source of feed for cattle particularly of weaker sections like landless /small / marginal farmers. Each family has equal access to these resources in the village. In the past, group of villagers were taking care of such lands and maintaining them, but after abolition of this system, these properties became no body’s property and are now in denuded condition.

In hilly areas, due to the availability of common property resources (CPRs) in mountain areas, local inhabitants do not customarily depend on cultivated fodder. Even large landholders find cereals and other cash crops to be far more remunerative than cultivated fodder crops. Dairy farmers have their own ways of responding to the scarcity of fodder. They may feed a large part of the available nutritive fodder to lactating animals in milk and may give some cereal and
purchased concentrate to dairy animals. Alternative management systems are evolving, including stall feeding, the planting of fodder trees close to the homestead, and cultivating grasses on private land unsuitable for growing food crops.

Crop residues are a major source of roughage for both improved and local dairy buffaloes in India. Although India ranks first in the world regarding milk production, a majority of the cattle and buffaloes are under smallholder production system and feeding practices are traditional. Farmers choose their own ingredients and prepare their own formulations, believing that by this practice they are able to pay more individual attention to their cattle. Since considerable proportion of cattle and buffaloes are less producers due to their genetic make-up, the farmers feel high-quality compound feed (industry feed) may not necessarily generate a significant improvement in productivity. In past, this has hampered growth of the cattle feed industry because most farmers are reluctant to use compound feed fully. However during recent times, the dairying is shifting from traditional to semi-commercial or commercial mode, in which the animals are fed with compound feed procured from market.

One of the major constraints in dairy farming is inadequacy of feed (quantity and quality) to sustain milk production, particularly during the dry season. The area under fodder crops in India has stagnated at about 8.5-9.0 million hectares during the past decade and accounts for only about 4.6% of the total cultivated area. The projected green fodder and dry fodder demand for 2020 is 1134, 630 million tones where as the availability is expected to stand at 406 and 473 million tones leaving a short fall of 64 and 25%, respectively. The concentrate requirement at 2020 has been estimated to be 81 million tones on dry matter basis while the estimated availability is around 45 million tones leaving a gap of 45%. Although significant quantities of crop residues are produced their quality cannot meet the nutritional requirements of dairy cows.

A growth rate of 10% is estimated in the feed sector and the demand for cattle feed was about 10 million tons in the year 2010. As per the norms of feeding each cattle with 1.5 kg of concentrate for maintenance and 1kg concentrate for every 3 kg of milk production and this implies that the potential market for cattle feed would be about 45 million tons annually. Majority of cattle and buffalo are fed homemade feed mixture, concentrates and grazing and the existing market for cattle feed is only about 5.5 million tons. The private sector produces about 1.2 million tons and dairy cooperatives produce about 2.5 million tons of feed and the rest is produced by home mixes in the unorganised sector. The cooperatives produce low cost feed that is sold to the farmer-members, numbering around 10 million of a total of about 80 million farmers in the country (Pal and Siddiky, 2011).
Nepal
Though straw constitutes the major feed constituents for dairy animal feeding and its intact nutritive value is very poor, the urea or ammonia treatment of straw is virtually nonexistent despite it has been emphasized by the government extension services. Chopping of straw mixed with green forage whenever available is the commonly adopted practices by the dairy farmers.

Both in peri urban areas and in the villages, uses of terrace risers and bunds for fodder production is common. Napier and Amliso are common forage species used in terrace risers, bunds and roadsides open land. Tree fodder plantation for feeding animals during dry period is a common practice across hills of Nepal. They are important source of green feed for dairy animals during that period. In subsistence dairy animal production system, foliage collection from nearby forest (government or community forest) is also very common. Recently open land under community forestry has been extensively utilized for fodder production in the milk grid areas of the country.

Pakistan
In Pakistan several feed resources are available for dairy animal feeding however, like other countries in the region; it is also deficient in feed and fodder. Crops, shrubs, grasses and agro-industrial wastes are being utilized to fulfill nutrient requirement of dairy animals. Green forages mainly comprise of summer and winter fodders (locally called Kharif and Rabi fodders respectively) and rangelands. It is estimated that ranges have 38% contribution in feed resources for livestock in Pakistan which is second major contribution after fodder-crop residues, which has 51% contribution (Khan et al., 2013). Dry roughages include hay, straws, stovers, hulls and silages. Fodders are mainly grown in areas where irrigation water is available. In times of scarcity of fodders, leaves of certain trees are also lopped for animal feeding. Popular fodders cultivated in Pakistan are Berseem (Trifolium alexandrinum), Lucerne (Medicago sativum) and oats are the popular fodder crops in winter. Other winter fodders are mustard, rape seed and turnips. Popular summer fodder crops are sorghum, maize, millet and cow pea. A few hybrid multi cut fodders are also becoming popular. However, majority of the farmers are still adopting the conventional system of fodder production with a limited number of fodder varieties that creates periods of abundance and serious scarcities. The non-conventional feed resources traditionally used for animal feeding include resources like several agro-industrial by-products and wastes from sugar industry, food and fruit processing industries, and residues of soybean, pea nut, and mustard and sun flowers.

Three types of concentrate feeds are commonly used in Pakistan for animal feeding. Cereal product based concentrates are high in total digestible nutrients (TDN) as compared to their digestible protein (DP) value. Both vegetable-based
and animal-based concentrates are rich in DP as well as TDN but the quality of dietary proteins available in animal-based concentrates is superior to vegetable-based concentrates. An estimate indicates that the nutrients available in the country do not meet the requirements of the livestock. Overall, Pakistan faces a deficit of feed sources, as demonstrated by shortages of 57.24 million tons of dry matter, 28.62 million tons of TDN, and 1.76 million tons of DP. The country’s formulated feed industry is underdeveloped. Compared with an estimated annual demand of 40 million tons, only about 0.20 million tons is produced.

**Sri Lanka**

Natural grass is the most common fodder available for ruminants in Sri Lanka. Grassland farming is not popular among the livestock farmers due to shortage of land and the poor income derived from the dairy cattle farming at present. The uncultivated areas under the government are used for animal grazing to great extent. The most common grass varieties are Panicum repines, Cynodon dactylon, Axonopus compressus are widely distributed. In addition different Brachiaria spp (some are introduced to the island) are also available in the coconut triangle and low county wet and dry zone of the country. The most common natural grass found in the upcountry is Kikiyu (Panisetum clandestinum) which has very high protein content but low in energy. Further to that a wild species of Panicum maximum commonly known as ‘Guinea A’ is spreading in a very aggressive manner all over the country except in the higher altitudes. Guinea grass has been the backbone of the dairy industry of mid country during last few decades.

In addition to the various natural grasses many improved varieties of different grass varieties have been introduced to Sri Lanka. Various tree fodder varieties are available in the country for feeding ruminants. Paddy straw is available everywhere for feeding dairy animals during feed scarcity.

In addition to the fodder and grasses, a large quantities of various agricultural by products such as rice bran, coconut poonack, broken rice and several industrial by products are available and still imported to the country to fulfill the requirement. Earlier, Maize was imported in large quantities for use in the animal feed industry, however, the present policy of the Government encourage farmers to grow maize.

**Breeding**

The number of artificial insemination (AI) done in Bangladesh was 3.21 million in 2009 and about 40% of the cattle breeding are covered by AI. There are 21 district artificial insemination centres and 500 artificial insemination sub-centres are functioning throughout the country.

India has one of the largest breeding infrastructures in the world (48 frozen semen stations, 3297 bulls and 98283 Artificial Insemination centers) with total
production of about 67 million frozen semen straws every year and 54 million artificial inseminations covering about 25% of the breedable population. However the availability of breeding bulls and frozen semen straws is far less than the requirement. To achieve national target of 50% AI coverage by 2021-22, the country require high number of superior bulls. The quality semen production must reach to 140 million doses from the present dose of 67 million doses. The major limiting factor in achieving the required numbers of frozen semen straws production is the availability of quality bulls. As such the availability of quality bulls is very limited and the situation is further amplified by the poor quality semen produced by the breeding bulls especially the crossbred bulls.

In Pakistan, the availability of breeding bulls is limited both for cattle as well as buffaloes. Breed improvement work in Pakistan has mainly revolved around artificial insemination programmes. Although, Pakistan has well developed infrastructure for the AI service in the country, the actual coverage of AI in cattle and buffalo is very less. At present, the network of Artificial Insemination (AI) services consists of 8 Semen Production Units (SPUs), more than 200 main AI centers and nearly 830 AI sub-centers located in different parts of the country. This AI network, however, can provide breeding coverage to only 10-12 percent of the breedable population of cattle and buffaloes maintained in the country (Hasnain & Usmani, 2006b). At local level, semen for cattle (Sahiwal and Red Sindhi) and buffaloes (both Nili-Ravi and Kundi) is being produced. Holstein-Friesian and Jersey cattle semen is being produced locally as well as imported from other countries. The programmes that were in place earlier to supply proven bulls to field conditions for natural mating have now been discontinued.

The AI coverage in Nepal is said to be around 8.06% in cattle and 1.55% in buffaloes. For improving the milk production, frozen semen straws of Brown Swiss, Jersey, Holstein, Ayeshire, Tirentase breeds of cattle and Murrah buffalo are used. On an average 0.3 million doses are imported from other countries for AI of cattle and buffaloes. The conception rate has been reported to be around 49%. The number of AI in cattle and buffaloes has been steadily increasing over the years. AI is more in cattle compared to buffaloes in Nepal. Currently Annual AI has reached well above 150 thousands and upsurge in the demand of AI has been noticed.

In Sri Lanka, according to the available information only less than 15% of the breedable cows is inseminated per year with a success of 26-28%. The highest AI coverage has been reported in the wet zone and the upcountry areas while application of the technique in dry zone has been somewhat neglected.
Health

Animal health plays an important role in animal production. In turn animal health is influenced by factors such as disease resistance, nutrition, and the animals’ environment. Parasite infestation is a major economic disease as it affects milk production to a considerable extent. Intestinal worm infestations and external parasite, mainly tick infestation were the major problems in cattle.

The most common infectious diseases of cattle in Bhutan are foot and mouth disease (FMD), hemorrhagic septicemia (HS), black quarter (BQ), and respiratory diseases. Control of diseases such as FMD, BQ, and HS are carried out through regular mass vaccination. The incidence of sub-clinical mastitis in eastern Bhutan was found to be about 24%. Infestation by liver fluke is very common in rice-growing areas while roundworm infestations are more widespread. Periodic deworming is advocated to control these parasites. Veterinary services are provided to farmers for prevention of these infestations through the livestock extension centers.

In India, the control of dairy animal diseases is encouraging for the facts that the country eradicated Rinderpest, the most dreaded disease that vanished herds of cattle. But there are several other diseases like FMD, IBR, HS, BQ, Anthrax and Brucellosis and parasitic diseases that are prevailing in the country leading to huge loss to dairy industry. Although the country has vast and effective network for animal health management across the country, the outreach of veterinary health care services to the dairy farmers especially in some areas is also low. Lack of awareness and timely non-availability of inputs for preventive measures leads to very high incidence of diseases and epidemics in the country. It has been estimated that losses due to brucellosis cost India at least Rs.350 million every year on account of food animals. The annual economic losses incurred by dairy industry on account of udder infections have been estimated about Rs. 6053.21 crore. Out of this, loss of Rs. 4365.32 crore (70-80 %) has been attributed to sub-clinical version of udder infections. A well-planned and operational mastitis control programme is urgently needed to ward off huge economic losses to dairy industry. For success of the programme, a close monitoring during its implementation along with good husbandry practices is essentially required. There is a strong need for health education to all the personnel engaged in control programme as well as the farmers (Kumaresan et al., 2013). The direct economic loss due to FMD in India is estimated at Rs. 20,000 crore a year. Small, marginal and unorganized dairy sector of the poor farmers are most sufferers by this disease. If FMD alone is controlled, the milk production can be increased by at least 5% in the country.

In Pakistan, the most important endemic diseases of livestock are foot and mouth disease, hemorrhagic septicemia, black quarter and rinder pest in cattle. The
economic losses by vector borne diseases have been estimated to be Rs. 79 billion that is approximately equivalent one billion US$ in the Punjab alone and economic losses due to various livestock diseases were estimated to be Rs. 8.4 million per district per year in the province of Punjab. Although there are numbers of veterinary hospitals and dispensaries throughout the country, their benefits have not trickle down fully to the farmers.

In Nepal, though sporadic information is available, comprehensive analysis of the economic loss due to these diseases and parasites in the country is still lacking. As Rinderpest disease has been eradicated from the country, Hemorrhagic septicemia, FMD, mastitis, infertility, metabolic diseases and internal parasites are some of the economically important diseases prevalent in dairy animals. FMD is important disease and as in many developing countries, FMD is endemic in Nepal. The estimated economic losses due to FMD infection in Nepal is around USD 5.36 million per year (Thakuri, 2012).

In Sri Lanka, among the notifiable diseases, Black quarter has not been reported from the country in recent times but FMD is reported occasionally. Animals are periodically vaccinated against contagious disease such as FMD, Hemorrhagic septicemia and Black quarter by the DAPH at no cost to the farmer. However, common diseases namely mastitis, parasitic infestations and calf-hood diseases namely, Calf pneumonia, Salmonellosis, worm infestations and Navel-ill is common in many herds and the economic losses due to such diseases are not fully recognized. Many farmers neglect treating the affected animals due to high cost involved.
Chapter 7

MILK COLLECTION AND MARKETING CHANNELS

Afghanistan

Most of the milk in Afghanistan is produced by smallholders with less than 5 animals, their production units are widely dispersed in rural areas while most markets are located in urban areas. The traditional way of processing surplus milk in remote areas is the production of “Quroot” a dried product on the basis of sour yogurt and wheat flour, and “Maska” (ghee) which have fairy long shelf life. Collection systems vary according to the prevailing condition and the first step might be a simple collection point with shade provided to minimize temperature rise. In most villages there is some form of small scale milk processing by farmers and traders where the milk is brought. The final products are then taken to the retail store for sales purpose.

Dairy sector in Afghanistan still applies the traditional methods with limited use of machinery. There are investment opportunities in Afghanistan especially in major cities such as Mazar-e-Sharif, herat, Kandahar, Nangarhar and Kabul for industrializing this sector. Afghanistan imports large quantities of dairy products such as yogurt, fresh milk, cheese and condensed whey.

Bangladesh

The milk marketing and processing systems in Bangladesh are not yet developed in a large scale. The milk marketing channels in Bangladesh are not fully organized. The proportions of milk selling by the farmers through different channels differ from place to place. The typical milk marketing channels reviewed by Ghosh and Mahajan (2002) are described below.

Traditional Milk Marketing Channel: Producers may sell their milk directly to local market, neighbors and tea stalls. But most of the times, they sell their surplus milk to the Gowala. Aratdar is a commission agent and mediates between producers and Gowlas/retailers, consumers as well as hotels and restaurants. Aratdars charge a fixed amount of commission form of monetary value or milk from producers. Retailer includes the milk trader who buys milk from the Aratdar, Gowala or group or individual producers in the market and supplies this milk to the city consumers, hotels and restaurants. The middlemen are performing a role of marketing the rural milk to urban places, but the price of milk is not fixed and the middlemen do not pay farmers regularly. Price varies from place-to-place and from season-to-season. Gowala also cannot ensure the fresh milk for the consumers as they start collecting milk from the rural area early in the morning
and sell this to the urban area until the evening without any preservative measures. Mixing water and milk powder in the fresh milk is very common practices among the Gowalas in this marketing channel.

**Cooperative Milk Marketing Channel:** Bangladesh Milk Producers’ Cooperative Union (BMPCU) Ltd was registered in 1965, covering the entire country as its area of operation. There are 1836 primary milk producers’ cooperative societies affiliated to the Union. The Union has 4 dairy plants of (Baghabari, Tekerhat, Shibpur and Dhaka) and 28 chilling centres with 300,000 litres total capacity. The Union collects about 250,000 litres of milk daily; 160,000 litres is sold as liquid milk and the balance is converted to various products like milk powder, butter, ghee, cream, curd, ice cream, rashomalai, chocobar, for examples.

Milk is procured through primary milk producers’ cooperative societies and collections are made in the morning and afternoon. Cooperative union transports milk to the plant and payment is made every seven days, on the basis of percentage of fat to the society. Society makes payment to its members every seven days.

Like BMPCUL some other private entrepreneurs Pran dairy, BRAC dairy, Aftab dairy and some other small processing dairy industry also initiated their milk collection and processing approach through cooperative gateway.

**Bhutan**

The marketing of dairy products is limited to the management of local surpluses and shortages. There is no organized marketing system; occasional unplanned surpluses are bartered, or sold for cash at a high price. Organized marketing of livestock products is very limited and exists only in certain parts of the country. However, changes in dairy production are taking place especially in the areas with access to marketing opportunities for dairy products; especially the ever-expanding urban population provides better marketing opportunities. The fresh whole milk is sold directly to the processing units and collection centers, providing an important source of cash income (Phanchung et al., 2002).

Almost all local dairy products are marketed through an informal, unorganized system. Imported dairy products are marketed through a comparatively well-organized, but nonetheless inadequate system. However, there are now three milk processing units (MPUs) of different capacities in Bhutan and some milk collection associations in the east for marketing fresh milk. Fresh milk marketing is mostly confined to places with access to processing facilities and peri-urban areas where producers take advantage of the urban population who buy milk for fresh consumption. Fresh milk consumption is not common in Bhutan, except in the south and some parts of western Bhutan, where a certain proportion of fresh milk is used for preparing sweet tea or occasionally for fresh consumption.
especially for children. The major proportion of milk produced in the country is processed into butter and cheese, which form a substantial part of the Bhutanese diet. The butter is mostly used for preparing the salted butter tea (suja) that is commonly consumed by the majority of the Bhutanese population and the cheese is used as an important ingredient in almost all Bhutanese curries. Some processed cheese (mostly imported) is consumed direct. In general, the major proportion of locally produced milk is processed, and consumed and/or marketed as butter and datse cheese—a cheese processed from the buttermilk after extracting the butter. There is significant production deficit in milk production as huge amounts of milk powder, processed butter, and cheese is imported from India.

There are three basic marketing channels in Bhutan.

*Producer/farm-local consumer/market:* Most dairy products in Bhutan are marketed through this channel wherein producers sell their products directly from their own farms within the village to neighbors, to people from other villages, and also to consumers in close-by urban areas. These producers have virtually no marketing costs as the consumers come to the farm and collect the milk in their own containers. Generally, the farmers retain around 42% of milk in winter for processing into butter and cheese and in summer around 21%. These processed products are traded within the village or taken to local markets when they are visited for work or to purchase other necessities.

*Producer—middlemen/traders —consumer outlet:* Sale of fresh whole milk through this channel is not common. Producers with large herds process the milk and sell the products, mainly butter and cheese, to middlemen or traders who take it to the domestic market centers who in turn supply to contract retailers and vendors on a wholesale basis.

*Producer — milk processing units/collection centers — retailers — consumer outlet:* The sale of milk and milk products through this type of structured or organized system is currently limited to a few areas only, and is more common for the sale of fresh liquid milk. The producers sell their milk to the processing units or collection centers at a fixed price.

**India**

Indian dairy Industry achieved the status of producer-owned and profit manufacturing co-operative system. Of the total milk produced, about 50% is retained by the producers for domestic consumption leaving about 50% as the marketable surplus. The dairy industry handling the marketable surplus of the milk can be broadly divided into the organized sector and the unorganized sector. The organized dairy sector refers to the dairy units registered under the Milk and Milk Products Order (MMPO), 1992 (revised in 2002). These dairies have each capacity of handling over 10,000 litres of milk per day. These organized dairies are under cooperative, private or other (like government dairies) sector. As on the
31st of March 2011, there were 1065 registered dairy plants in India of which 765 plants were in private, 37 in government and 263 in cooperative sectors. The installed processing capacity was 73.25, 4.04 and 43.25 million litres per day in private, government and cooperative sectors, respectively, with total combined processing capacity of 120.5 million litres a day. Although the white milk revolution was spearheaded in the country by the cooperatives, today just a little over 7% of milk is handled by cooperatives. A very large number of private sector companies/firms have been established in the country since liberalization of the dairy sector in 1991. The share of the total milk processing capacity by private sector is 61% of total installed capacity as against only 36% in cooperative sector.

Over 1 lakh collection centers supply milk to the organized sector dairy plants, which have a good share in milk products market. But the products manufactured are mostly western-type in nature like table butter, cheese and different types of milk powders. Although the organized sector has entered the market of indigenous milk products like ghee, shrikhand and paneer, these markets are mostly controlled by un-organized sector. The organized sector, especially cooperative dairy sector, disposes large portion of milk as processed liquid milk and only surplus is converted into products. The unorganized dairy sector comprises numerous, small and/or seasonal milk producers/traders (popularly known as ‘halwai’) that are not registered under the MMPO. These small units handle 10,000 litres of milk per day or less and are involved in selling raw/boiled liquid milk as well as manufacturing and selling mainly indigenous milk products like peda, barfi, rasgulla, khoa, paneer, ghee, etc., usually at the local level, but have a major share in these milk products. There are no official records on number of such unorganized dairy units.

The organized dairy sector procures around 30% of the marketable surplus (around 15% of national milk production) while the unorganized sector handles about 70% of the marketable milk. In the organized dairy sector, the co-operative and government dairies account for about 60% share while private dairies’ share is about 40%. The organized dairy sector has been paying increasing attention on improving quality of products and enforcement of rules, while the unorganized dairy sector largely remains unattended. As a result business operators in the unorganized sector pay little importance to quality, except some reputed sweetmeat shop owners who maintain relatively good quality standards.

The dairy co-operatives in India are a three-tier structure following the Anand Pattern, including village-level milk-producers’ co-operative societies, district-level milk-producers’ co-operative unions, and state-level milk-producers’ co-operative federations. The cooperative movement led to inclusion of more than 14.78 million farmers under its ambit of 1,48,965 village level dairy corporative societies by March 2012 (Thakur-Verma, 2013). It is found that the dairy co-
operatives play a vital role in alleviating rural poverty by augmenting rural milk production and marketing (Rajendran and Mohanty, 2004).
Of the milk traded, over 50% of the milk is in the form of liquid milk, another around 35% in the form of traditional products and the remaining 15% is accounted for by butter, milk powders and other western type manufactured products (Figure 21). The demand for packaged, branded traditional milk products is increasing rapidly. The further growth of the market for value added indigenous dairy products is expected largely for ethnic foods such as flavoured milk, dahi, paneer, lassi, kheer, etc. Key dairy products manufactured in the organized sector include processed/packaged milk, UHT milk, milk powder, and other dairy-based, value-added products like butter, cheese, curd, buttermilk, fruit yoghurts, etc. The processed dairy products market is likely to grow at a rate of 15%. Further, processed dairy products are expected to contribute 30% to the dairy industry by 2016 in value terms. The organized and branded milk market, dominated by a large number of cooperative players, is likely to grow to a magnitude of 73% by 2030 according to CII-McKinsey (2013).

![Figure 21: Product-wise Consumption Pattern](image)

**Market Scenario:** The total dairy market in India was estimated to be INR 3,000 bn (US$ 60 bn) in 2011 comprising nearly 40% of the total Food & Beverages market. Of this the organized dairy segment was 20% or INR 600 bn. implying a significant opportunity for growth for the next decade or more. The total dairy market is projected to grow by a CAGR of 10-11% to nearly INR 5,000 bn or (US$ 82 bn) by 2016 (Source: AC Neilson and India Food Guide, Edelweiss, February 2012; http://foodprocessingindia.co.in/milk-and-milk-products.html). Once a net importer, India has now turned a net exporter of dairy products. India’s Export of Dairy products was 1,59,228.52 MT to the world market for the worth of Rs. 3,318.53 crores (USD 546.1 million) during the year 2013-14. Saudi
Arabia, Bangladesh, UAE, Egypt, Nepal, Singapore, Algeria, Yemen Republic are among the top export destinations for dairy products from India. India’s import of dairy products during 2012-13 and 2013-14 accounts for US $ 30.65 and 35 million. Milk and cream concentrates, whey powders, and cheese are major products imported among dairy products. New Zealand, France and Australia are the major suppliers of dairy products to India. (Source: DGCIS Annual Exports data). India has two distinct competitive advantages, which can be leveraged to enhance exports: (1) Low farm gate prices, and (2) Proximity to milk deficit markets. Amongst the important milk producing countries, Argentina, New Zealand and Australia have slightly lower farm gate prices than India, but these account for only 10% of the global milk production. Moreover, India has a locational advantage to serve milk deficit areas in the neighboring countries in south East Asia and Southern Asia. In addition, demand for milk products in these markets are expected to be strong.

The Indian dairy sector contributes greatly in income and employment generation (Staal et al., 2008). The informal and small-scale dairy industry generates significant labour at each stage, from production through procurement, transport, processing and marketing of milk, much of which is available to low-skilled individuals who may have few other employment opportunities. Compared to processed markets, which employ many fewer workers per unit milk, the traditional market is seen to be comprised of labour-intensive enterprises with an enormous potential for employment generation in the rural sector. Processing, including manufacturing of different dairy products, such as butter, ghee, milk powder, ice-cream, kulfi, khoya and paneer, engages only 1.2% of dairy workers in both the formal and traditional informal sectors. A little over 6% of workers in the dairy sub-sector are engaged in selling of milk and milk products, including both wholesaling as well as retailing. As expected, a higher proportion of workers in the dairy sector in rural areas are engaged in production-related activities (95%) and less than 1% in processing. But in urban areas about 31% of the dairy workers are engaged in selling of milk and milk products.

The levels of employment generated in the informal milk markets are significant. Aroud 11 milk vendors (dudhias) are engaged for handling 1000 litres of milk on a daily basis. Nearly all the jobs created are in the form of self-employment. Due to value addition, some 20 jobs are created for the same quantity of milk in sweet shops, which employ 2-3 permanent workers, or more than 13 jobs in creameries which produce indigenous milk products, such as paneer, butter, ghee, cream and dahi, and collect milk from 13-14 vendors on average. Retail sales of packaged milk generate some 5 jobs per 1000 litres daily; on average a retailer employs 12 persons who carry milk sachets in cycles/rickshaws and deliver them door-to-door. Also, due to value addition, the employment generated in local ice-cream production is high, estimated at some 26 jobs per 1000 litres of milk handled.
daily, of which 1.7 are in the form of service providers to maintain and repair equipment (Staal et al., 2008).

These volumes translate into an estimated 1.8 million jobs, with milk vendors accounting for 55% of the total followed by halawis (36%). This excludes persons employed in the formal processing sub-sector but includes retailers of pasteurized milk (milk sachet sellers/retailers). This figure amounts to some 10% of the estimated total direct employment of 18 million in the dairy sector.

Supply Chain of Indian Dairy Industry

Marketing and disposal of milk is particularly difficult for small-scale producers. In general, the small-scale milk production system in India could be broadly classified into four main categories: 1) Dairying for home consumption, 2) seasonal surpluses of milk are sold as liquid milk or converted into market sales of storable household products, 3) small-scale dairy farming where milk and milk products are converted into market sales and commercial dairy farming where the animal holding is comparatively large and milk and milk products are converted into market sales. The disposal of milk throughout the country is carried out according to following four methods:

- Through dudhias (small traders) who buy good quality milk from producers at a lower price and then sell it in the urban markets at a higher rate, earning more profit, none of the margin returning to the producers;
- Through private enterprises owned and run by an individual or in partnership as a private business, such enterprises make huge profits and exploit small producers by buying their milk through agents or middlemen;
- Through state-owned city dairies; these dairies also depend on traders and cannot benefit producers, mainly because the producers do not have a direct link with such dairies;
- Through collective ownership; for example self-help groups/milk bulking groups/dairy cooperatives (Sinha, 2007).

Supply chain in Indian dairy industry starts from supplying inputs for dairying in form of feed, fodder and veterinary aids for cattle and buffalos. The milk from the large medium and small scale farmers is collected either by milk vendors or by the milk collection Centre (various milk cooperatives societies) on the daily basis (Figure 22). A fairly complex supply chain model exists in the Indian Dairy Industry. If we try look at it separately for the unorganized and organized sector of the dairy industry then it would be rather easier to understand the intricacies of the entire trade (Jaisridhar, et al., 2012). The unorganized dairy market in India is about 80% and still the dudhiya and halwai dominate this section of the market. In this traditional system the milk produced is directly sold to the consumers at the farm. The other mode is that milk is collected by the milkman from the
farmers and then supplied to restaurants or *halwai* for further processing from whom the consumers take the value added processed milk products. These milkmen also sell and supply milk directly to the consumers at their door steps (Jaisridhar, et al., 2012). The quality of the vendors’ milk and milk products is not guaranteed. Largely sold in loose form, it is often adulterated with several additives to control spoilage.

In organized sector channel, the milk produced is deposited by the farmers in the collection centres at the village level and then this milk is pooled and transferred to the chilling centres and bulk milk cooling units where the milk is cooled to 4°C. Then it is filled into insulated tankers and transported to the processing plants where the milk is tested and transferred into milk tankers. This milk received is then processed into various categories of liquid milk and value added products. Then the packaged milk is transported to the milk parlors or retail outlets from where it reaches the consumers. In case of the value added milk products having longer shelf life, they are transported to the distribution centres and carrying and forwarding agent (C & F agent). The C & F agent then supplies the required amount of stock to the various retail outlets and milk parlors from where consumers can buy the products (Jaisridhar, et al., 2012).
Figure 22: Supply Chain of Indian Dairy Industry (Source: Technopak Analysis, 2010)
Several models of milk supply chain have been tried in organized sector to 1) create sufficient incentives for farmers to produce the required quantity and quality of raw materials, and supply the produce as stipulated in the contract (rather than sell elsewhere); 2) to provide required farm inputs and technology needed and the question of who bears what costs (and risks), which should be transparent and well understood; 3) to access high quality processing technology; 4) to address new and changing consumer demand through effective market intelligence; 5) to attract capital for investment and growth through adequate performance and capability; and 6) to pay overall, adequate attention to the crucial issues of ownership, organization, management and quality control. Gandhi and Jain (2011) made a detailed review of these models, which is given below:

Model 1: The AMUL Cooperative Model

The AMUL cooperative Model evolved out of a successful dairy cooperative initiative in the Kaira district of the Gujarat state of India, in which, ownership of the venture is with the farmers on a cooperative basis. It has a 3-tier organization structure, with primary cooperatives at the village level, a cooperative union at the district level, and a cooperative federation at the state level. Broadly, the village cooperatives take the responsibility for procurement of the produce from the farmers, the district union is responsible for transportation and processing, and the federation is responsible for marketing and strategic planning and investment. The cooperatives are governed by a rotating board of farmer-elected directors, but the management is done by professional managers who are well empowered and largely independent. The main function of this cooperative society is to collect milk from the milk producers of the village and make payments based on quantity and quality. It also provides support services to the members such as veterinary first aid, artificial insemination breeding service, sale of cattle-feed, mineral mixtures, and fodder seeds, and sometimes training on animal husbandry and dairying.

The district-level Milk Union is the second tier under the three-tier structure, which has membership of Village Societies of the district through their Chairmen, and is governed by an elected Board of Directors. The Board of Directors elects a Chairman and appoints a professional Managing Director and staff. The main function of the Milk Union is to procure raw milk from the Village Societies of the district, transport it from the villages to the Milk Union owned dairy plant, and process it into pasteurized milk and other milk products. It also undertakes significant supportive activities such as veterinary services, breeding services, cattle feed and other inputs to the village societies and producers, and undertakes initiation, training and supervision of the village level societies.
The State-level Federation is the apex tier under the three-tier structure, which has membership of Milk Unions of the State through their Chairmen, and is governed by an elected Board of Directors from among the Chairmen of Milk Unions. It elects a Chairman and appoints a professional Managing Director and staff. The main function of the Federation is the marketing of the milk and milk products manufactured by Milk Unions. The Federation manages the distribution network for marketing of milk and milk products and maintains the supply chain network. It also provides support services to the Milk Unions such as technical inputs, management support and advisory services.

Member producers bring milk to society every morning and evening. The quality and quantity of milk are assessed, and the amount payable to each producer is worked out. When the producer comes to the centre in the evening, she/he is paid for morning delivery and for the milk delivered in the evening; money is paid the next morning. Apart from the daily cash income, members also get bonus and a difference in price at the end of the year. Amount of bonus is pro rata to the value of milk supplied by the producers at the society. The society also makes profit on the milk it sells to the union and gets difference in price. The entire profit of the society is generally not distributed to member producers. A part is allotted for the developmental activities within the village and maintenance of the society. Societies also act as dissemination modes for various activities of the union such as member education, production enhancement. The staff at the societies is also trained to undertake the veterinary first aid and artificial insemination. Bulk cooling units and chilling centres are often set-up along these milk routes. Milk is collected by unions from villages twice a day with the help of contracted private transport vehicles. Milk from the society is measured for its quantity and quality (Fat and SNF i.e. Solids-Not-Fat) and is paid on this basis. Payments to the societies are made every 10 days.

AMUL or Anand Pattern of Cooperatives represents a methodology of building and sustaining an economic enterprise and has ensured high levels of patronage, cohesiveness, governance and operational effectiveness. The cooperative model enjoys commitment of the farmers, and cost-efficiency in raw material production and procurement. It also extensively engages with the small farmers as well as the landless rural poor who may keep even 1-2 animals, and is reported to contribute significantly to rural incomes and employment through its three-tier organization (Gandhi and Jain, 2011).

Recently, the GCMMF – Amul has taken the initiative of installing Automatic Milk Collection Unit Systems (AMCUS) at village societies to enhance the transparency of transaction between the farmer and the cooperative society (Bowonder, et. al., 2005). AMCUS makes entire milk collection process automated. Right from weighing and measuring the fat of the milk to make
payments to the farmer and generate analytical reports in all the steps are taken

care of in the solution. These systems also gave cooperative societies a unique

advantage by reducing the processing time to 10% of what it used to be prior to

this. These initiatives supports integration of the value chain activities destined

towards the “Better Management Practices”. The Dairy Information and Services

Kiosk (DISK) is another initiative that has been started. A National Milk Grid has

been formed by linking deficit areas with the surplus areas thus assuring proper

marketing of the milk and hence an assured return to the rural producers.

**Model 2: Nandini Model**

Another similar model on the cooperative lines is “Nandini” of the Karnataka

Cooperative Milk Producers' Federation Limited (KMF) (www.nandini.com/

aboutus.htm) wherein Village dairy co-operatives are promoted in the

AMUL/Anand pattern in a three tier structure with the Village Level Dairy

Cooperatives forming the base level, the District Level Milk Unions at the middle

level to take care of the procurement, processing and marketing of milk and the

State Milk Federation as the Apex Body to co-ordinate at the State level.

Coordination of activities among the Unions and developing markets for milk and

milk products is the responsibility of KMF. However, unlike in AMUL, the

marketing of milk in the respective district jurisdiction is organized by the

respective milk unions. Surplus/deficit of liquid milk among the member Milk

Unions is monitored by the Federation. All the Milk and Milk products are sold

under a common brand name “Nandini”.

The milk unions also provide the technical inputs such as veterinary emergency

services, animal health camps, and vaccination to milch animals, animal feed and

fodder seeds, artificial insemination (AI) services, training, etc., at subsidized

rates or free of cost to their members. The major challenges facing the Nandini

model are inadequate processing facilities, difficulties in maintaining quality of

raw milk under the prevailing conditions, increasing costs of transportation and

processing, un-heathy competition from private dairies in procurement,

inadequate roads and power infrastructure, etc. which mainly stem from a

relatively limited role of the Federation (compared to AMUL), and as a result,

inadequate scale economies and lack of support in larger roles such as marketing,

investment and logistics (Gandhi and Jain, 2011).

**Model 3: Nestle Model**

The Nestlé model supports a system of sustainable dairy farming with regular

milk payments and sustainable methods through a positive impact on the

community and rural economy as a whole (http://www.nestle.com/

AllAboutNestle.htm). In this model, a milk district is set up involving negotiation

of agreements with farmers for twice-daily collection of their milk, installing

chilling centers at larger community and collection points or adapting existing
collection infrastructure, arranging transportation from collection centers to the district’s factory and implementing a program to improve milk quality (Gandhi and Jain, 2011).

To ensure quality, Nestlé undertakes training and has manuals detailing good farm practices for each district. The farms are audited regularly to make sure the right practices are followed. Nestlé provides technical support to farmers to guide them in reaching the quality/competitive standards. Testing is done at the collection centers and cooling centres (Goldberg, 2006). Nestle works to have a stable business relationships with farmers. Surpluses present a challenge for Nestlé and the farmer. Nestle tries to offset the expense of buying up surplus in the spring season against the security of a steady supply at a stable price throughout the entire year.

The company has stringent quality specifications. Company staff members regularly monitor milk quality and the performance on contractual obligations, and the farmers obtain feedback on milk quality at the collection points. Company technologists determine quality in laboratories with samples being taken in the presence of both the farmers and the company representatives. Company is not obliged to collect milk that does not meet the quality standards specified in the contract. The contract also allows the technologists to punish the producer with a 30 days ban and if antibiotics are found, the price of milk is reduced by 15 percent. Repetition of any discrepancy is considered a serious breach of contract. Farmers have the right to complain through registers located at each collection point if he/she believes there is a problem. The system still works because it provides an assured market at remunerative prices for the milk to the farmers.

Unlike `AMUL model’ wherein the primary milk collection centre is the village cooperative society, that is owned and directly accountable to the dairy farmers themselves, in the `Nestle model`, the job of sourcing milk from farmers is done not by a cooperative society, but by a private commission agent appointed by the company.

**Model 4: Heritage Foods**

The Heritage Group based in Andhra Pradesh was founded in 1992 and it is a fast growing private enterprises with three-business divisions viz., Dairy, Retail and Agri, under its flagship company Heritage Foods (India) Limited (HFIL) (http://www.heritagefoods.co.in/ dairy/home.html). Heritage has established a supply chain which procures milk from farmers in rural areas (mainly in Andhra Pradesh and some parts of Karnataka, Maharashtra and Tamil Nadu). The Heritage model’s starting point is harnessing the current milk collection centers which are also rural retail points and use them to penetrate into the rural market.
Two-way or reverse logistics is used to transfer and sell goods from the urban markets to rural markets and with this direct retail presence also mobilize milk procurement. This enables economies in supply chain cost, serves both the rural customer and producer that improves penetration in the rural areas.

It connects to consumers through representatives (who are also milk collection representatives of Heritage) who sell consumer goods. The objective is to reach popular fast moving consumer goods (FMCG) products and quality groceries at affordable prices to the interior villages across South India, also leveraging on the milk procurement network. Besides milk, vegetables and seasonal fruits are also produced and procured through contract farmers and reach pack houses via collection centres strategically located in identified villages. The collection centres undertake washing, sorting, grading and packing and dispatch to the retail stores through distribution centres. Other features of the model are promotion of annual crop calendar of sourcing that seeks to ensure higher annual income per unit area; technical guidance- agri-advisory services, regular training of farmers, credit linkage and input supply; package of improved farm practices for better productivity & quality; assured market at doorstep; assured timely payments; and transparency in operations.

The Heritage model provides an example of using the existing marketing points and chains for the purpose of agro-industry rather than building new/dedicated chains. This may achieve faster roll-out and reach. It also provides an example of using two-way or reverse logistics for improving the efficiency and economics of the supply chain. Both these methods are not seen in the AMUL, Nandini or Nestle models (Gandhi and Jain, 2011).

Model 5: Mother Dairy

Given the potential markets for liquid milk in the big cities, Mother Dairy were set up in all the four metros -Mumbai, Kolkata, Chennai and Delhi by National Dairy Development Board (NDDB). Even though Mother Dairy is not owned by the farmers, it is associated with the Anand Model co-operative setup. The objective was to help those cooperatives who needed help to the process and market the milk.

Mother Dairy sources its entire requirement of liquid milk from dairy co-operatives - it buys the liquid milk from state federations. Mother Dairy pays almost 70 per cent of the market price to the milk suppliers. The payment is made through cheques and the milk suppliers receive the payment within 10 days. The surplus from the remaining amount is shared among the Mother Dairy, state federations, district unions, and the village-level societies. Mother Dairy is reported to have brought benefits to the farmers. However, the reach of the
Mother Dairy model to the farmers depends substantially on the efficiency and the effectiveness of the cooperatives since it does not connect with the farmers directly. On the other hand it assists the farmer bodies to market the milk in the vast markets of the major urban areas – a capability many of them lack. It also undertakes the necessary investments for processing and distribution which is difficult for some of the farmer bodies to make (Gandhi and Jain, 2011).

**Model 6: Hatsun Model**

Hatsun- a private enterprise in Tamil Nadu procures fresh milk directly from the farmers. To facilitate it in this process Hatsun has around 4,500 'Hatsun Milk Banks' (HMBs) covering over 8,000 villages and 3 lakh plus farmers pouring their milk everyday. Per liter price of milk is determined with the help of a two way price chart based on Fat and SNF content. (http://www.hatsun.com/procurement.html). Based on the quality and the number of liters poured by the farmer, his or her total amount is calculated. Once all the tests are done, each farmer's data (quantity, Fat & SNF% along with the farmer's unique number) is entered in a scan-able data sheet. This sheet is sent to the Hatsun's computer center where it is scanned and based on the same the farmer is paid every week on a fixed day of the week. The entire farmer's data base is managed through a state of the art computer software system. Hatsun operates more than 800 rural milk procurement routes having fixed timing to pick up milk cans for each HMB/village in the morning and evening. Once all the farmers have poured their milk, the milk is collected in cans and loaded on to the trucks on the precise time fixed for picking the cans at the HMB. After collecting milk from all the allotted HMBs the milk procurement vehicle arrives at the Hatsun Milk Chilling Center (CC). At the CC the milk is tested organoleptically, weighed, and a sample is taken for more detailed tests and pumped to the chilling unit. Once the tests are completed and the suitability of the entire CCs milk is confirmed to meet Hatsun's strict quality norms, the milk is loaded into a road milk tanker and sent to the dairy. At the dairy the milk is put through more tests before taking it up further processing.

**Nepal**

Liquid milk consumption among households in urban areas is widespread. About 88% of urban households consume fluid milk regularly and another 7% occasionally. The average quantity purchased is 1.03 litres/day per household, with 1.1 litres in the Hill and 0.9 litres in the Terai regions. However, the habit of drinking milk regularly has not yet been developed in Nepal. In urban areas, the use of milk for tea is popular; about 94% of households use milk for tea whilst 60% drink it as milk. For milk products, consumption is primarily concentrated on
traditional products like ghee (45% of households) and Dahi (33% of households). Proportions of households consuming other milk products are very small, e.g. dairy whiteners 6%, butter <3%, cheese <3%, sweets <3% and other products <1% (Joshi and Tarak Bahadur, 2001). The demand for milk and milk products is expected to grow by about 11 percent per annum.

In earlier days, the producers used to go house by house and deliver the required quantity of milk to the households. Dahi filled in clay containers were produced by some traditional dahi makers and milk-based sweets were prepared by traditional sweet makers (halwais). But after the advent of Dairy Development Corporation (DDC), the scenario began to gradually change with the increasing supply of pasteurized milk and modern dairy products such as cheese, butter, ice cream etc. Many new sweet shops also started to emerge. Now, particularly in the urban areas, the situation has completely changed because many dairies in the organized sector have come up with varieties of dairy products. Processed liquid milk is the prominent product of the dairy industry as almost 80 percent of milk collection in the formal sector is used to produce processed milk. Besides, different dairy products are also imported to cater the consumers’ demand.

The key actors in the formal dairy value system include milk producer farmers, Milk Producers’ Co-operatives Societies (MPCS), Milk Collection Centres (MCC), and milk processing plants/cheese factories. Firstly, there are rural farmers and their function is to be engaged in milk production (FAO, 2010). The next are MPCSs established in the rural areas. Farmers from the surrounding villages carry their milk production to the nearest MPCS where their milk is received, measured, recorded and samples are taken for quality check [mostly fat and solid-not-fat (SNF) test]. After receiving milk from all farmers, it is then transported by available means (vehicles, porters, carts, rickshaws, bi-cycles, horses) to the nearest MCC or cheese production center (in case of cow milk cheese). Some of the MPCSs have their own chilling system where they chill the milk, deliver it to the DDC and/or private MCCs or sell in the local market. A few MPCSs located near to the milk processing plant directly deliver milk there. In case of Yak cheese, the farmers under cheese production centers directly deliver their milk in the centers where milk is instantly processed to produce cheese and butter.

Next are the MCCs or cow cheese production centers where milk received from the MPCSs is measured, recorded, and platform quality control tests are performed that generally include organoleptic test, fat and SNF test, clot-on-boiling (COB) test, etc. Occasionally, adulteration test is also performed. Milk in the MCC is cooled by either instant chilling system or in the bulk milk cooling
vat. In the cheese production centers, milk received from the MPCSs is directly processed to produce cheese, butter and other dairy products such as paneer, and sweets. Milk from the MCCs is transported to the milk processing plants in insulated bulk milk tankers (FAO, 2010). Then there are milk processing plants. Here milk from the MCCs and MPCSs after being received in the reception desk firstly undergoes quality control tests and quality passed milk is then measured and cooled prior to keeping it in an insulated milk storage tanks for further processing and producing pasteurized milk and milk products. After processing, milk and milk products are kept in cold store for sales.

The last actors are the milk selling booths/dairy shops and institutional buyers. The milk booths sell only milk to the consumers/tea shops, and dairy shops mostly sell milk products to the consumers. The milk selling booths operate for only 2-3 hours in the morning but the dairy shops are open from morning to evening. There are some such shops also which buy milk from the booths in the morning and put it in the refrigerator and sell it later with extra charge. The institutional buyers include hotels, supermarkets/departmental stores and fresh houses. Among these, hotels use milk and milk products for their own purposes whereas supermarkets/departmental stores and fresh houses sell milk products to the consumers. Milk also passes through the informal channel. In this system, individual farmers or the contractors are the main actors who directly deliver milk to the individual households/tea shops/sweet shops etc (FAO, 2010). The milk marketing supply chain of Nepal is depicted in figure 23.

The milk produced by smallholder farmers is mostly processed into cheese. Yak cheese is produced by DDC as well as by the private sector. All the cheese plants are located in the alpine regions of the country, where cheese is stored under natural refrigeration. Cheese is produced using Swiss technology and the production is seasonal, meaning that cheese is produced only for seven months of the year and that the plants close down during the five months from December to April. Yak cheese making by the private sector is growing and the production has surpassed the DDC’s production in the recent years. There are about 21 yak cheese producers in the private sector in four districts (Joshi and Tarak Bahadur, 2001).
Figure 23: Milk marketing supply channel in Nepal
(Source: FAO, 2010)
**Pakistan**

Pakistan’s milk production system is highly fragmented and dairy enterprise is dominated by the private sector, with the government playing a regulatory role. About 95 percent of total milk produced from small-scale rural and peri-urban holdings with 2-3 milking animals. Over 90 percent of the marketed milk is collected and marketed unprocessed through the informal market by a multi-tiered layer of marketing agents (Zia, 2006).

Approximately, 80% of the milk is produced in rural areas, with peri-urban and urban areas accounting for another 15% and 5%, respectively. Buffaloes and cows are the major milk producers. An estimated 66.84% of total milk is produced by buffaloes, 30.81% by cows, and 2.35% from small ruminants. Out of the total milk available for human consumption, only 30-40% reaches urban markets, while the remaining 60-70% is consumed in the rural areas. Only about 3-4% of total production is processed by the processing industry and marketed through formal channels. Raw milk is the primary dairy product marketed in the country. A relatively small percentage of the milk is also marketed and consumed in processed forms. The traditional processed products are mostly produced and marketed by the informal sector, and include; dahi, lassi, butter/makkhan, ghee, khoa, sweetmeats, ice cream and other confectionaries. The formal processing sector is responsible for the production of UHT and powder milk.

The milk marketing chain in Pakistan is reviewed by Zia (2006). The milk market in Pakistan can be categorized into three segments; rural, urban, and international markets. Almost 87% of the total milk in Pakistan is produced in rural areas. Currently, an average of 9-12 million liters of milk or 30-40% of production in the country is being absorbed by the urban markets. The milk marketing chain in Pakistan is exclusively dominated by the informal private sector, which market 97% of milk in raw form by informal agents. Only 3-5% of total production is processed and marketed through formal channels. The milk marketing chain consists of various agents, each performing a specialized role at the relative node in the chain. These consist of milk producers, collectors, middlemen, processors, traders, and consumers (Figure 24).
Milk produced by the rural dairy farmer is marketed to both urban and rural consumers. In case of the rural market, milk is sold either to a *dodhi* (milk collection agent), or directly to milk retailer, or tea shop located either within the village or in close vicinity. These shops also procure milk in bulk quantities on contract basis from the *dodhis* in order to sell it onwards to the local consumers in the form of raw milk, or as processed goods such as *dahi*, *lassi*, butter, etc. In some instances, they also procure UHT or milk powder. However, as most consumers purchasing milk in the rural areas have direct access to a dairy farmer, milk retail shops are usually found only in relatively large villages. On the other hand, while catering to the urban market, the rural dairy farmer usually sells milk directly to the *dodhi* or a dairy processor owned VMC, if the latter is located in the area. The *dodhi* goes on to sell milk to the contractor. In some instances, the procurement agents of the contractor would even buy directly from the farmstead. Once purchased, milk is hauled by the contractor to a de-creamer shop where cream is separated from milk to be sold onwards to ‘*Halwais*’ and ‘Bakers’, who in turn use the cream to manufacture products such as sweat meats, ghee, butter, etc. Once de-creamed, the milk is transported to retailers in the city.
Alternatively, since the processors procure milk based on quality criteria, the contractor directly sells whole milk to the procurement agent of a processing plant instead of skimming it beforehand. The processor sells the milk in the form of UHT, pasteurized, or milk powder. Other products manufactured by processors are butter, cream, ice cream, flavored milk, etc. Both the halwai and processor sell milk either directly to the urban consumer or use milk retailers as a distribution channel. After procuring milk from contractors, halwais, and processors, retailers serve as points of sale for consumers in the city for raw milk and traditional by products such as butter, dahi, lassi, etc. In some exceptional cases, the dairy farmers transport milk directly to the cities, thereby integrating the functions of middlemen into their operations and visit a de-creamer shop to sell the cream before selling the milk to the retailer.

Most of the milk in the country is marketed in raw, liquid form. According to industry estimates, only 3-5% of the milk is marketed as processed milk. Currently, there are more than 20 dairy processing plants operating in the country, which process UHT or pasteurized milk, powdered milk, butter, cream, lassi, etc. However, UHT milk is the most predominant form of product produced by these plants. The processed milk marketing chain is the only formal milk market existing in the country. After procuring raw milk from rural farmers through their procurement agents, either directly through setting up of VMCs or having contracts with various milk contractors, the processing plants produce processed milk. This milk is packaged at site using modern technology and stored in company warehouse to be hauled through the marketing chain using a sophisticated distribution system that delivers the processed milk to retail stores all over the country. A considerable amount of the processed milk is consumed in urban localities, whereas some processed milk is sold in far flung rural areas that are deficient in milk production.

Another aspect of the processed milk marketing chain is the import of powder milk. Due to a wide consumer base, Pakistan faces milk shortages every year. To meet these demand shortages, milk is imported from various countries. The milk is brought into the country by licensed local import agents who obtain certain quotas are allowed to import powdered milk. After procurement they sell to retail stores through a formal distribution channel of registered distribution agents, etc. Some of this milk is also purchased by bakeries and confectionaries to be used as raw material in various consumer goods. However, the greater portion of the milk is bought by the end consumers at the retail stores.

*Sri Lanka*

The formal milk collection system in Sri Lanka revolves around collecting small quantities of milk from large number of small holdings scattered over relatively long distances. Producers who are not able to sell directly to consumers or retail
outlets must rely on either private (informal) milk collectors, co-operative milk collection, or formal milk collection centres linked to formal dairy processors. Distance from major urban markets may or may not affect market access, depending on milk production density. The formal milk sector consists of public or private enterprises such as MILCO (now Kiriya), Nestles group, Nestles Lanka and small processors. The “informal” or raw milk market consists of sales directly to individual consumers and private milk collectors who then sell milk either to collection centre or to customers and institutions. The typical supply chain for milk in Sri Lanka is shown in figure 25.

The marketing of milk in Sri Lanka is complex and varied. There are individual farmers who sell direct to processors, consumers, hotels, cafeterias and canteens. Cooperatives are organized primarily for the purpose of collecting and selling milk to either hotels or processors. The formal, or processed dairy, market consists of small dairy cooperatives, larger local cooperatives, district dairy cooperatives, dairy cooperative unions and networks of collection points and milk chilling centers operated by cooperatives or the main dairy processors. Most farmers are not members of cooperatives or farmer societies. There are a few large-scale processors who have organized farmers to sell their milk to them (Ranveera, 2009). The processor is an important player in the dairy value chain. The processors have played the role of promoting the growth of the dairy subsector and offering the market to the MCCs and the farmers to buy their milk. The processors buy raw milk and produce various milk and milk products. Some of the products the processors produce include pasteurized fresh milk, long life milk, lacto, butter, yogi drinks among others. The processor enters into supply agreements with various retail outlets such as Shoprite, Spar supermarkets among others (Achchuthan, and Rajendran, 2012). The primary business of the formal private sector stakeholders are milk powder and other processed milk product imports. Nestlé is an exception, which runs a substantial milk powder-processing operation based on locally procured milk.

Contributing to the informal market are small private milk collectors, small local processors of traditional dairy products, retailers and dairy producers who sell directly to hotels and restaurants or to consumers. Small local processors of modern dairy products also contribute to the supply.
Figure 25: Supply chain for milk in Sri Lanka (Source: Ibrahim et al., 1999)
Chapter 8

STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS (SWOT) FOR DAIRY DEVELOPMENT IN SAARC MEMBER COUNTRIES

The SWOT analysis of the current dairy scenario of the SAARC member countries would reveal the following:

**Strengths**

- Constant and sustainable growth (high milk production with high growth rate) despite limited investment from public and private sector
- Mega biodiversity and large bovine population - The vast dairy animal population could prove to be a vital asset for the region. Unlike many other natural resources which may deplete over the years, a sustainable livestock production system will continue to propel the economy.
- Variable agro-climatic conditions and diverse dairy animal production systems (Zero input – low output, low input – moderate output, intensive input – high output)
- Low production cost – Dairy farming in the region thrives largely on crop residues and agricultural by products keeping the input costs low. Labor cost is also fairly low making the industry fairly cost competitive. The cost of production of 100 kg milk is around 20 USD in India compared to 68 USD in Japan and 58 USD in Canada.
- Male are still used for draught agriculture (considerable proportion of agricultural land are cultivated by animals)
- As the milk productivity of dairy animals is low, there is a vast scope for improvement of the milk production and consequently increased marketable surplus of milk for processing.
- Very big domestic market - purchasing power of the consumers is on the upswing with growing economy & continually increasing population of middle class.
- Milk consumption in several countries is regular part of the dietary programme irrespective of the region and hence demand is likely to rise continuously.
- Large number of dairy plants in public and cooperative sectors besides several others in the private sector is coming up.
Vast pool of highly trained and qualified technical manpower is available at least in some countries at all levels to support R&D as well as industry operations.

**Weaknesses**

- Though cross breeding programmes have significantly improved animal productivity, milk production system in many parts of the region is still largely dominated by low yielding animals.
- Wide gap between availability and requirement of progeny tested proven dairy sires.
- Shortage of feed and fodder; continuous reduction in area under fodder production.
- Poor condition of roads and erratic power supply remain a major challenge for procurement and supply of good quality raw milk. Furthermore, raw milk collection systems in certain parts of the region remain fairly underdeveloped.
- Maintenance of cold chain is still a major handicap. For organized marketing of milk, the milk produced is required to be transported to nearby processing plant which incurs cold storage and transportation costs which are quite high.
- Majority of producers is unaware about scientific dairy farming, clean milk production and value chain.
- Absence of comprehensive and reliable milk production data, impact assessment studies are almost non-existent, investments in dairy research is also not commensurate with returns and potential.
- Poor governmental policy in some part of the region.

**Opportunities**

- Technology driven production enhancement in low producing animals.
- Expanding market will see creation of enormous job and self employment opportunities.
- Economy is growing in the region, consequently, the investment opportunities are also increasing continually.
- Demand for dairy products is income elastic. Continued rise in middle class population will see shift in the consumption pattern in favour of value added products besides the growth in demand for liquid milk.
- Untapped indigenous milk products market-greatly improved export potential for indigenous as well as western milk products.
Value addition in raw milk; functional food - Opportunities for utilization of by products of the dairy industry for manufacturing value added products.

Public private partnership in milk production, processing and value addition.

**Threats**

- Danger of extinction of valuable bio-resources-excessive grazing pressure on marginal and small community lands has resulted in almost complete degradation of land and Indiscriminate crossbreeding for raising milk productivity could lead to disappearance of valuable indigenous breeds.
- Developed countries are providing huge subsidy & incentive for export.
- Organized dairy industry handles very less percentage of the milk produced. Cost effective technologies, mechanization, and quality control measures are seldom exercised in unorganized sector and remain as key issues.
- Middlemen still control a very large proportion of the milk procurement. Serious efforts need to be taken to eliminate them from the supply chain.
- Lack of government interest in the dairy sector development.
Chapter 9

SUBSISTENCE TO COMMERCIAL DAIRYING: KEY CONSIDERATIONS

The dairy farming scenario in SAARC member countries is witnessing a gradual transformation during last two decades from traditional production system to commercial production system. The commercial production system consists of keeping high producing crossbred cows and/or buffaloes starting from about 10-20 in number to 100 or more and managed under better housing, feeding, breeding and healthcare. Many of these farms have been established by educated youth both rural and urban and have been financed by banks. The corporate firms have also shown keen interest in investing in dairy farming and some corporate owned dairy farms are already in existence and many more are in the process of being established. Several of these which were hitherto engaged in milk procurement and processing are also venturing into milk production in view of the rise in demand and issues of quality of milk procured from outside.

The major driving force behind this trend has been the liberalization of the economy and the globalization of trade with the signing of WTO agreement. This led to the enhancement of milk processing capacity manifolds as a result of entry of many big business houses in the milk sector and setting up of a large number of milk processing plants. Along with this the increase in population and income levels specially of large middle class led to a spurt in demand of quality milk and milk products in the country and rise in milk prices which fueled the need for venturing into dairy farming and made the dairy farming a remunerative business proposition. Along with dairy farming at medium to large scale an another perspective gaining ground is the integration of farming with milk processing as well as marketing under a single entity so as to ward-off the middlemen in milk supply chain and maintain quality at every stage of milk production, processing and marketing thereby making available quality milk and milk products to the consumers at reasonable rates. Large investors in dairy farming are also eyeing the opportunities of by-product processing and diversification in the long run in the areas of biogas production, power generation, source of superior germplasm in the form of upgraded cows and buffaloes and semen of tested bulls.

Why commercial dairying?

In the recent past, several countries witnessed increase in income levels of the population, especially of large middle class that led to a spurt in demand of quality milk and milk products in the region. To meet the projected demand of milk and milk products, the region has to equip itself to witness the
transformation in dairy sector from subsistence oriented to commercial/semi-commercial oriented activity. Such transformations, although not universal and restricted to some pockets, are already taking place in few Asian countries. Under the transformed system of dairying, the quality control of produce is easier than in the traditional system. Also, the entry of several big business houses in the dairy sector and setting up of a large number of milk processing plants led to the enhancement of milk processing capacity manifolds, which otherwise has been negligible. Along with dairy farming at medium to large scale, an another perspective that is gaining ground is the integration of farming with milk processing as well as marketing under a single entity to ward-off the middlemen in milk supply chain. This also helps in maintaining quality at every stage of milk production, processing and marketing thereby making available quality milk and milk products to the consumers at reasonable rates. Rise in milk prices also fueled the venturing into dairy farming and made the dairy farming a remunerative business proposition. Taken together, it is evident that without much transformation in the existing milk production system, we may not be able to meet the demand for milk and milk products in future. Further, there are some indications that the milk procurement, processing and marketing by Multinational companies is better than the traditional unorganized marketing system in terms of money paid to the farmers and retail price paid by the consumer.

**What are the controversies?**

While increasing the scale and intensity of dairy operation, there are possibilities that the interests of smallholder dairying are compromised. Thus while facilitating the transformation; it needs to exercise some mechanisms to protect the smallholders since more than 70% of the milk production comes from smallholder-managed dairy sector. Further they are the repository of well recognized indigenous dairy breeds and complete transformation to commercial activity may lead to erosion of the existing dairy animal genetic resources. Moreover, scaling up such dairying would require huge investments in terms of money, labour, mechanization, and management and nutritional inputs. However, it is also true that the majority of the currently existing stakeholders are not fully prepared for such transformation. Only by facilitating the large scale commercial dairying, it may not be possible to obtain inclusive growth; however boosting the smallholder dairying as a whole and commercial dairying at identified areas would keep dairying as an instrument of inclusive economic development. To achieve this, it needs to have a stringent mechanism/legislation in place that protects the interests of large smallholder population while facilitating scaling up commercial dairying.
Why these controversies arise?
These controversies arise because of the prevailing dairy production system and its contribution to the nutritional and livelihood security of large population. Unlike developed countries where large scale dairying dominates, a majority of the population in developing countries depend upon their livestock for nutritional security. For instance in India, there are mainly three types of dairy producers (i) Dairy animal dependent population or pastoralists, who rely on their animals to provide food, income, transport and fuel (ii) Small scale mixed farming population, who depend greatly upon animals for their livelihoods and dairy animals play a central role as a source of food, income and critical inputs for agricultural production (such as draught power and manure) and (iii) Peri-urban milk producers, who live in the fringes of urban areas in order to better access labour, income and services to cope with their limited access to production resources. Any step that would compromise their livelihood would bring out serious effect on economic development and food security and thus any transformation to private large scale activities often invites controversies or debate.

However, as the world is getting integrated into one market, quality certification is becoming essential in the market. There are few commercial dairy farms and plants in the region, which have successfully obtained ISO, HACCP certification. There is scope for introducing newer large scale dairy farms and plants with the help of private sector investment. Further investments can take place in manufacturing dairy processing equipment, packaging equipment and equipments for biotechnology related dairy industry. All these open up avenues for boosting dairying in the region, however allowing a majority of share with private sector may compromise the interests of public. While facilitating the private sector investment, the regulatory authority should also formulate and implement policies that control the uncontrolled expansion of private sector in dairying and to facilitate co-operative model for sustainable dairying.

Dairy Development - The way forward
In view of the ever increasing demand for milk and milk products, it has become necessary to develop regional milk grid in all SAARC regions for sustainable income of the milk producers, consumers and those related with the dairy industry. Among the SAARC member countries, there are countries which are self sufficient in milk production (India and Pakistan) compared to other countries. The export of dairy products within the region is considerably low. Except India and Pakistan, other countries in SAARC region import milk to meet their demand. Thus, the major aim of any milk grid development should be to link the deficit areas with surplus areas to overcome the inter-regional difference between the supply and demand for milk. On the other hand, if one analyze, even
the self sufficient countries also the full potential of dairy animals have not been exploited owing to deficiencies in breeding, nutrition, health and other management capabilities. Thus dairy development programmes in SAARC member countries should aim to improve the productivity of dairy animals through all possible interventions and also to address the issues related to milk marketing so that the producers get premium price for their produce. Any step towards the dairy development in SAARC member countries should aim to address the problems of smallholder dairying on one hand and promoting commercial dairying on the other hand without compromising the interests of smallholders.

**Bringing sustainability in smallholder dairying**

Although the SAARC member countries are blessed with huge dairy animal population, elite germplasm, wealth of input resources, manpower, diverse agro-climatic conditions and institutional mechanisms for dairying, the potential of the dairying has not been harnessed to its maximum extent. Dairy development should be given priority as any development in this sector will not only increase the milk production in the region but will also improve the livelihood and nutritional security of millions of people. There are some inherent impediments in dairy development in the region. For instance, the dairy sectors in the region are mainly in the hands of smallholder mixed crop–livestock farms and most of the milch animals are fed on crop by-products and residues. This type of production system has its own constraints in terms of low productivity, lack of proper feeding and animal health care, an inadequate supporting infrastructure for supply of feed and veterinary medicines, procurement, processing, storage, transport and marketing of milk. The primary milk producers are concentrated in rural areas and have limited access to marketing and infrastructural facilities. Meeting the stringent quality standards of dairy chains is the biggest challenge in front of the smallholders as their production system, at least partly, does not follow the “Clean Milk Production” practices. This makes it difficult to ensure stringent milk quality parameters. Improvement in the quality and competitiveness of milk and milk products depends on technological intervention at the grassroots level and the synergy of technological and organizational improvements coupled with operational changes at all levels of the value chain.

Although recent days witness transformation of dairying from small scale to commercial or semi-commercial scale across the region, it is well understood that smallholder dairying will continue to exist in large way in SAARC member countries as this system of dairy production is mostly related to livelihood of a major mass of people. Thus any dairy development program should aim to address the problems of smallholders in one hand and to facilitate commercial dairy production on the other without compromising the interests of the
smallholder. To make the dairying sustainable and more productive, the need of the hour is to realize its potential and to evolve a comprehensive and integrated dairy development policy for the region. Equally important is the strong determination and total commitment to effectively implement the policy.

The major constraints perceived in dairy development in the SAARC region (Ahuja et al., 2013) are:

- Shortage of improved dairy animal germplasm and breeding facilities
- Shortage in feed and fodder
- Insufficient dairy animal management skills
- Poor outreach of animal health services
- Inadequate dairy extension services
- Limited access to affordable credit
- Poorly regulated milk procurement and marketing
- Meager processing and value addition
- Import of powder milk from abroad

**How to bring about dairy development in the given situation?**

*Transforming from “Animal number driven” to “Technology driven” dairying*

While the livestock population is increasing, the land for feed and fodder cultivation is shrinking. Unless a fine mechanism to reduce the population of low yielding nondescript cows is not developed and implemented, in future, it would be difficult to meet out the feed and fodder requirement. Shifting from “Animal number driven dairying” to “Technology driven dairying” is the major challenge in front of personnel engaged in dairying in the region. Vertical expansion of dairy animals is the most promising option for overall dairy development.

For improvement of various breeds of cattle and buffaloes there is a need to form Breed Societies/ Breeder Associations on the pattern of western countries. These societies could work in close cooperation with various research and developmental agencies including Non-Governmental Organizations (NGOs) for improving the livestock productivity. Interactive programmes involving field recording, progeny testing and data bank should be taken to supply information on availability of semen, bulls, females etc. for consistent genetic improvement of livestock. To effectively monitor these programmes, there is an urgent need for linking them with bio-informatics centers at state, national and international levels. There is also scope for identifying the unique genes specific to indigenous dairy animal genetic resources using the molecular techniques. It is expected that by the use of such technologies more number of superior animals per unit time can be obtained by reduction in generation interval which could further increase the pace of genetic advances by increasing the intensity of selection.
The strategy for increasing milk production should focus on increasing animal productivity rather than animal population, which calls for continuance of well-proven technologies such as crossbreeding with superior germplasm coupled with emerging reproductive and molecular technologies including multiple ovulation and embryo transfer (MOET), use of sexed semen and cloning for production and faster multiplication of superior germplasm of elite animals. Embryo transfer technology enhanced by multiple ovulation and estrus synchronization, allows acceleration of genetic progress through increased selection intensity of females. Technologies like Ovum Pick-up allows repeated pick-up of immature ova directly from the ovary without any major impact on the donor female and the use of these ova in in-vitro fertilization. This also makes much greater use of genetically valuable females at a very early age may substantially increase genetic progress. The use of DNA/gene markers may assist in selection of the superior germplasm to produce the next generation.

Cloning of elite dairy animals and bulls could be an option to increase the number of high producing animals. Now we are premier in the world in buffalo cloning technology. At the National Dairy Research Institute, India the world's first cloned buffalo calf was born on February 6, 2009 using the somatic cell of a newborn calf whose age was only two months. World’s second cloned buffalo calf, Garima, produced by hand guided cloning was born on June 6, 2009 using somatic cell of a fetus obtained from slaughterhouse. Another cloned calf (Garima-II) using embryonic stem cell as donor was born on August 22, 2010. A cloned male calf ‘Shresth’ was born on August 26, 2010 and at very young age (around 19 months) he started ejaculating good quality semen. The cloned female buffalo calf Garima produced a viable young one “Mahima” and this set record proving that cloned animal can reproduce normally and can give birth to normal offspring. Moreover, the Garima has given birth to Mahima at the age of 28 months, which is very appreciable compared to the average age at first calving of Indian buffaloes. In the world, it is the first calf born from cloned buffaloes, produced through hand guided cloning technique. These success stories indicate the potential use of cutting-edge reproductive technologies for vertical expansion of quality dairy animals.

A suitable and sustainable breeding policy should be in place to achieve overall genetic improvement of livestock. Also its judicious implementation at field conditions is of paramount importance to effectively harness the benefits of upgrading and crossbreeding.

Facilitation of smallholder’s participation in modern dairy supply chains

Smallholding dairy farmers are constrained by low productivity, lack of access to markets, capital, inputs, technology and services. Further, to meet out the stringent standards for exporting the dairy products, improving the production
quality and traceability becomes inevitable. Though the technological back up and trained man power are available to some extent, the issue lies with bringing in the smallholders into the quality umbrella, which is the most consistently faced problem as the contribution of the smallholders to the total milk production is enormous and the trend is expected to be continued in near future also. Due to several campaigning and training programmes by the Government and other agencies, clean milk production at smallholder level is possible now at least in few places where co-operative movements is existing. However, the co-operatives handle very less proportion of milk produced in the region and middle man or contract procurers/sellers and local vendors handle substantial quantity of milk and enjoy a lion’s share of benefit (Rangnekar and Thorpe, 2002). Failure to address these constraints may depress domestic production and lead to an import upsurge.

The most successful co-operative AMUL model in India needs to be replicated in region for successful participation of smallholders in the modern dairy supply chains. For increasing the production of value added dairy products, the infrastructure will need to be further developed at the public, cooperative as well as at private sector level. The Institutes and Universities engaged in dairy education and research need to enhance their efforts to provide research support and human resources for large scale, diversified and quality production of value-added products. The traditional unorganized marketing of milk in smallholder system needs to be gradually shifted towards organized marketing for better and sustainable remuneration to the producers. Research input will also need to be provided for formulation of macro, meso and micro level policies and programmes to control cost of milk production and processing, facilitate flow of milk to the organized sector and strengthen the legitimate interests of various stakeholders in dairy sector.

**AMUL Model of co-operative based dairy development in India: A model for replication**

Indian dairying is a classic example for “production by masses” rather than “mass production”. The milk production is largely a subsidiary activity to agriculture in rural areas where farmers and landless labourers mostly maintain one to three milch animals and produce small quantities of milk, which makes the task of milk collection complex. Under this situation, forming dairy farmer’s cooperatives is useful in promoting dairy development. In most dairy cooperatives either a two or three tier system is adopted. The concept of milk co-operatives has been well structured with one village or a cluster of villages forming the primary cooperative. A group of many primary cooperatives forms a union, which can be a region or milk shed area. The third level is the unions joining up to form a Federation at State or National level. A well orchestrated co-operative model of dairy development, famously called as AMUL model in India, offers an
appropriate strategy for promoting sustainable, equitable and gender-sensitive smallholder dairy development. The salient features of the AMUL model include: (1) producer-elected leadership and decentralized decision making; (2) managed by professional managers and technicians, who are accountable to the member-producers through their elected leaders; (3) provision of all necessary inputs and services to member-producers at reasonable, often subsidized rates; (4) integrated production, procurement, processing and marketing; (5) continuous and concurrent audit; (6) cash payment to producers for their milk—daily or weekly; and (7) contribution to village amenities.

A complete package of inputs and services necessary for enhancing milk production is given to the members of the co-operatives. The package includes animal health care through both regular as well as emergency visits by veterinary doctors, AI, balanced cattle feed, improved fodder seeds, and extension education and training. Round the year assured market to the milk produced by the members is the most important feature of the model. In summary, the AMUL model is producer-oriented, people-centered and holistic encompassing the integrated development of production, procurement, processing, pricing, marketing, training and management. Moreover, it advocates the use of appropriate technical, economic and institutional instruments to promote smallholder dairy development.

Community animal management, milking and processing facilities: An option

The concept of community animal management system, which is being implemented in some pockets of India successfully, can be expanded to other countries in the region for the overall benefit of the small scale farmers and also to fulfill the increasing market demand with due consideration of the quality thereby bringing smallholders into the organized umbrella. The idea is to be conceptualized after making a ground level survey both for the production system of the locality and the socio-economic status of the farmers. The major constraint in adopting modern animal rearing techniques is the small holding of animal unit. The farmers with small animal units would never be at ease to adopt scientific management tools; hence they will be motivated to join the campaign. Locality having a milking cattle and buffalo population of 400-500 is to be identified as a single Module. The module will have a single shed for all the animals of the locality with all necessary facilities for modern scientific dairy management. All the animals will be equipped with proper identification no. and will also be insured. The modern feeding systems will be practiced as per the requirement e.g. total mixed ration, region-wise mineral mixture feeding, densified feeding for high yielders. Properly trained subject-matter specialists will be appointed for routine management practices. Automated Milking System can be installed with sensors and wireless network system, which otherwise is never possible in small scale dairying. All the required milk production parameters will be transmitted to a single server where it will be stored and retrieved to work as a database system. The database will be of immense help for field data recording system and the
sensors for various milk parameters can be used for early diagnosis of certain oncoming diseases like mastitis and many other metabolic diseases. As there is minimal involvement of human labour which otherwise can be diverted for more productive work, more revenue can be generated and also better the quality of product. The value added product will be marketed by the organization. The byproduct (cow dung and other waste materials) can be utilized for biogas production and slurry to be used as manure for the fodder cultivation. The profit will be distributed as per the total fat corrected milk produced (after standardization) from all the animals of an individual farmer.

Promoting commercial dairying
The biggest task in front of the dairy industry in the region is to transform, gradually and phase by phase, the unorganized dairy sector into a more profitable large scale dairying which insures the farmer’s profit and also safeguards the consumer’s interest both at price and quality level. The prevalence of large informal milk sectors in South Asia provide an effective, functional link between farmers and consumers that responds to demand, both urban and rural, demand for locally produced indigenous products, however, opportunities for up-scaling exist and should be explored (Dugdill and Morgan, 2008). The concept of large scale dairying which not only considers what we want from the animals i.e. the better quality but also what the animals want from us i.e. the well-being of animals. Commercial dairying in large scale would help in utilizing export avenues however; large scale commercial dairy animal production units are very less in the region. Although the region is bestowed with a competitive advantage in primary production of many products, their exports are constrained by low level of processing, distortions in trade and stringent food safety norms in the international trade. There are opportunities for promoting large landholder commercial production systems especially around urban areas to cater to the increasing demand for animal food products there. Although the concept of corporate large-scale dairying is considered to have a negative impact on the unorganized traditional dairy production system, time has come to promote commercial large scale dairying owing to the increasing demand and import of dairy products. Policy has to be evolved for smooth co-existence of both smallholder dairying and commercial dairying through participatory discussion.

The development of a commercially viable private sector with investment in modern livestock farming technology is vital to transform the present subsistence level livestock production into commercial livestock production. Public sector support in livestock rearing, veterinary extension services and increasing the supply of breeding animals need to be intensified. The government should be committed to encourage private sector and community participation in dairy production, value addition and marketing. To match with the production capacity, investments are also to be strengthened for production and supply of feed ingredients and fodder.
Chapter 10

STRATEGIES FOR BOOSTING DAIRY PRODUCTION

Now it is well understood that “Animal number driven” dairying may not fulfill the demand for milk and milk products in the region and the dairying need to reorient towards “Technology driven mode”. Since dairying is socially and culturally intermingled with farming community and offer livelihood and nutritional security to a major mass of population, this transformation in dairying cannot be made overnight. However, it is high time to develop policies and source the technological options for smooth transition of dairying towards commercial mode while protecting the interests of smallholders. Some of the major issues impeding the dairy animal productivity and technological options to overcome those obstacles are discussed here.

Genetic Improvement of the dairy animals

It is obvious that the individual animal milk productivity in SAARC member countries is very low compared with western countries. Although the region is blessed with huge dairy animal population and diverse production systems matching with the agro-climatic conditions, inadequate policy measures and implementation at end user level resulted in under exploitation of the production potential. There are potential breeds of dairy animals that can take the dairy industry up, provided appropriate technologies are effectively implemented and inputs are adequately managed to meet up regular market demand.

Conservation and utilization of potential dairy breeds

The first and foremost step in improving dairy animal germplasm would be to restrain the genetic erosion of valuable germplasm that is well adapted to the micro level production system. The dairy animal population in the region includes considerable proportion of non-descript animals. Therefore, it is required to explore such populations and all the populations deserving the status of the breed should be characterized, documented and registered so that proper breeding policies can be evolved. To protect and conserve the potential dairy breeds, an integrated conservation and genetic improvement programme of different breeds should be given priority by establishing nucleus farms for each breed in its native tract for superior animal germplasm production, testing and dissemination and to develop animal identification and performance recording under field conditions. Establishment of breed societies and ensuring their participation in breed conservation and improvement programmes would be a viable option. Proper conservation policies at both national and state level and mechanisms to implement at end user level needs to be in place (Srivastava et al., 2014).
Establishment of a regional database on dairy animal resources and information sharing among countries could be a step towards wider utilization of potential dairy animal germplasm across the region. To be more effective, a mechanism for export and import of dairy animals/germplasm especially of regional and international transboundary breeds need to be developed.

**Genetic improvement of non-descript cattle and buffaloes**

While improving the production potential of recognized breeds through selective breeding, it is recommended that side-by-side the production potential of huge masses of non-descript cattle and buffaloes need to be improved using identified improver breeds, preferably indigenous high producing breeds. Since the adaptability, survivability and the ability to produce moderate quantities of milk under the smallholder system are high in indigenous breeds compared to exotic breeds, the use of these breeds as improver breed is expected to improve overall milk production without much production and reproduction problems. Further some of indigenous breeds like Sahiwal, Gir and Red Sindhi have been shown to perform well under intensive system also making them a perfect choice as improver breeds in both smallholder and commercial dairy production in SAARC member countries. The emerging concept of A1/A2 hypothesis in milk claiming that A2 milk has benefits over normal milk is also an opportunity for the SAARC member countries since initial studies on indigenous cow (Zebu type), buffalo and exotic cows (taurine type) have revealed that A1 allele is more frequent in exotic cattle while Indian native dairy cow and buffalo have only A2 allele, and hence are a source for safe milk (Mishra et al., 2012; Monika Sodhi et al., 2012). All these above going discussion suggest the potential of improving non-descript cattle and buffalo populations in the SAARC member countries using well-recognized high yielding Zebu breeds for not only improving the milk production but also to harness the potential value of A2 milk market.

Wherever resources for intensive dairying is adequate/plenty, crossbreeding with exotic breeds can also be practiced but with proper monitoring so that the metabolic, infectious and reproductive problems that are more commonly encountered in crossbreds compared to Zebu cattle are kept under control. For the purpose of crossbreeding with exotic breeds, use of already identified and in-use breeds in respective countries can be continued.

**Buy back policy for improving the availability of breeding bulls**

It is now well realized that the availability of elite progeny tested breeding bulls are very much limited and the demand for semen of quality bulls are increasing drastically. The farmers who possess high yielding superior germplasm do not give much importance to the male calves born out of the elite females and thus highly valuable male germplasm is lost. A policy for procurement of such valuable male calves and developing them as the future potential sires need to be
in place to overcome the problem. Already few state Governments in India and Pakistan has initiated some schemes to harvest potential breeding sires from field and redeploy them for use in controlled breeding programmes. The following model (Figure 26) is proposed for effective use of male germplasm.

The identification of elite animals and their record assessment duties may be assigned to the local livestock expert who shall be the vested with the duties of screening the local animal population to find out the best females. He shall adapt the elite females in situ and provide all the necessary health care, breeding and feeding facilities as per the provision and once the animal calves, the farmer shall be trained about proper calf management measures. The farmer may be paid the premium value for the calf and then the calf shall be shifted to the state Government farm for proper management of the calf until it reaches maturity which then be shifted to the bull station for further screening for diseases, libido and semen quality. Once the bull passes all the required tests, he shall be inducted into the routine semen collection and AI program. In this way the valuable male germplasm, which would otherwise go unutilized, can be utilized to its potential (Srivastava and Kumaresan, 2014).

Figure 26: Buy-back model for effective use of male germplasm
Enhancing the percolation of artificial breeding facilities

Artificial insemination has played a pivotal role in the livestock breed improvement worldwide. In SAARC region, the coverage of breedable population under artificial insemination is not promising. Expansion of artificial insemination services can help meet the growing requirement of milk in the region. Development and promotion of breed improvement societies and encouragement of private sector are some of the steps which will help in expanding the AI services. Since availability of sufficient quantities of liquid nitrogen is the most important to maintain the semen quality and for semen transport to field conditions, the countries need to set up more numbers of nitrogen plants to minimize the shortage, and favoring early and easy delivery of semen straws.

To increase the coverage it is essential that required semen doses are produced. In this regard, \textit{in situ} production of semen straws in required quantity is to be promoted. The skill and technologies that are available in some countries of the region can be utilized for other countries as well. Similarly, the use of progeny tested bulls should be maximized.

Technical and financial support for expansion of progeny testing program for existing bulls, initiation of progeny testing program for other deserving breeds, promoting public-private partnership in progeny testing program, linking production of progeny tested bulls to the breeding program with farmers, technical and financial support to semen production centers and strengthening of selected AI centers are some of the steps can foster overall expansion of AI network in the region.

Promoting buffaloes as dairy animals

Buffaloes are the second largest source of milk supply in the world. Trends in world milk production over the past few years indicate that the volume of buffalo milk is increasing steadily at about three percent per year. At global level, the contribution of buffalo towards the total milk production is only 12.8% but in SAARC region, buffaloes are contributing about 52% of the total milk produced, therefore it can be considered as main species for milk production. Buffalo has paramount importance as the dairy animal of the region. The species is more productive due to higher percentage of fat in the milk and is more sustainable for rearing because of its better feed conversion ability and disease resistance. The average fat content in buffalo milk is about 7 to 8% while protein content in buffalo milk ranges from 4.2 to 4.5%. So in terms of energy, buffalo milk is making a greater food contribution than the actual volume of milk suggests. In addition, the buffalo has a longer productive life. The normal healthy female buffalo could have as many as 9-10 lactations, which is very much appreciable comparing to cows.
The SAARC member countries, especially India and Pakistan have the world’s best dairy type buffalo, the Murrah and Nili-Ravi which is capable of milk yields as high as 35 kg in a day. The buffalo of Murrah breed, which is described as the “Asian tractor”, is in fact triple purpose animal-for milk, meat and work. The Murrah buffalo is the finest genetic material of milk producing buffalo in the world. This breed has called the best dairy cows of the world in performance. The Murrah buffalo is originally from Rohtak, Jind and Hisar districts of Haryana; Nabha and Patiala districts of Punjab states of India; and in Pakistan, but has been used to improve the milk production of dairy buffalo in other countries, such as Italy, Bulgaria, Egypt and Thailand. Individual female animals produce an average of 3,000 litre-per-lactation. Many animals produce > 4,000 litres in a 300 day lactation. The potential for increased milk production therefore exists. Daily lactation in peak period is about 14 to 15 litters but up to 31.5 kg milk production had also been recorded. The elite Murrah buffalo produces above 18-litres milk per day. A peak milk yield of 31.5 kg in a day has been recorded from a champion Murrah buffalo in the All India Milk Yield Competition conducted by the Government of India (Srivastava and Kumaresan, 2014b). This underscores the potential of buffalo as a “dairy animal for 21st century” in the region.

Meeting out the nutritional demand of dairy animals

Feed is the major input in dairy animal production system. In value terms, it accounts for about 80-90 percent of the variable cost of milk production. The feed and fodder for dairy animal production in SAARC member countries mostly consists of crop by products and residues that depend on the regional cropping pattern. Where wheat and rice are the major crops, straw is the predominant dry fodder used for feeding dairy animals while berseem, sorghum, oats and native grasses constitute green fodders. The farmers feed their animals with mainly home-made concentrates comprising of wheat bran, rice bran and oilseed cakes. In areas where commercialization has started (peri-urban and urban areas) use of manufactured feed is prevalent perhaps, because more numbers of high producing animals are reared and increased availability of animal feed factories in the organized and unorganized sector. Mostly, the indigenous cattle and buffaloes are dependent on grazing to varied extent. Grazing is allowed on fallow, barren and forest land throughout the year while in cropped fields it is allowed only in the off-season. Despite some sporadic efforts by the government and other agencies there has been little adoption of planted fodders, particularly, because on the small land holdings with low crop productivity, the farmers have the priority for producing subsistence food crops. Except for a small number of commercial livestock farms, the use of balanced concentrate feed is negligible.
The empirical evidence from the field indicates that in the agriculturally under-developed regions, on vast majority of dairy farms, the average dry matter intake (DMI) is less than 2.5-3% of the animal body weight. In the agriculturally well-off regions, on a typical dairy farm, although the quantum of DMI is adequate in relation to the body weight of the animals, low dry matter intake has been reported for milch animals reared by resource poor small and marginal farmers. In case of dry animals, the DMI is often inadequate for proper maintenance of the animal, even on the dairy units of the medium and large farmers. Besides the inadequate quantity of feed inputs, the lack of balanced feeding constrains the realization of full production potential of the animals.

Although feed and fodder is one of the most important contributing factors for the dairy sector, development of this sector has not received the required level of focus in the past. Any attempt towards enhancing feed availability and economizing the feed cost would result in increased margin of profits to dairy farmers. Growing numbers of commercial dairy farms with high producing cattle and buffaloes resulted in higher demand for green fodder. Further the smallholder production system, where the dairy animal depends mostly on common property resources, is also constrained by degeneration of the original pasture grasses and decline in biomass productivity from these resources owing to excessive stocking pressure. A comprehensive strategy for rejuvenation of these important resources is required. The manufacturing of compounded cattle feed is by and large with the private sector agencies (both organized and unorganized) and dairy federations in some countries. However further promotion and coverage expansion of feed manufacturing plants through PPP mode is needed.

The available nutrient enrichment technologies are to be sourced and utilized for dairy animal feeding. In order to meet the nutritional requirements of animals, particularly high yielding animals, there is a need to increase the bioavailability of the feeds and fodders by increasing the research efforts in the area of feed processing using chemical, biological and biotechnological approaches.

Optimizing reproduction efficiency

Good reproductive performance is essential for efficient dairy production. For better reproduction efficiency, the females must grow rapidly to attain sexual maturity, initiate estrous cycles, ovulate and be mated by fertile males or inseminated with viable semen at the proper time, conceive, carry the fetus to term, calve normally and establish reproductive cyclicity within reasonable time. Analysis of the data on reproduction parameters in dairy animals in the region clearly indicate that the animals attain sexual maturity at later age, calve at a later age, conceive at very later stage of post-partum period and the conception rate is
also very low. The reproduction status of cows and buffaloes during post-partum period is the major factor that determines the reproductive efficiency. Due to impaired reproduction ability, the calving to conception (days open) period is prolonged, which accounts to extended calving interval. Among the problematic animals, in a study conducted in India, it was observed that the functional abnormalities (repeat breeding and anestrus) were very high (68.64%), followed by uterine infection (29.7%). Anestrous and repeat breeding in bovines are the two most serious reproductive problems affecting 30-40% of the total cattle and buffalo population. On a conservative estimate, it has been reported that India is losing 20-30 million tons of milk annually on account of anestrus and repeat breeding in cattle and buffaloes. Conception rate through artificial insemination in buffaloes is very less when compared with cattle. Delayed age at sexual maturity (31-33 months in Murrah against 18-19 months in Mediterranean buffaloes), poor expression of heat symptoms and uterine infection still remains as major issues in achieving high reproductive efficiency in buffaloes. Summer infertility characterized by high incidence of silent heat (even up to 70%) is more common in buffaloes. Application of protocols for pharmacological regulation and augmentation of estrus in dairy animals would help to reduce anoestrus, calving interval, synchronize return services and enhance embryo survival.

Male is more than half of the herd but often overlooked. There is a need for a huge number of genetically superior breeding cattle and buffalo bulls of milch breeds. On the other hand the sub-fertility problems in bulls are increasing. Out of several reasons, poor libido, inferior semen quality and poor freezability accounts significantly to culling of male animals leading to reduced availability of breeding bulls for semen production. Compared to the indigenous breeds, the problem is more in crossbred bulls. At least 50-55% of the ejaculates are not suitable for freezing owing to poor initial semen quality in crossbred bulls. The situation is further aggravated by increased rejection rate of bulls owing to poor semen quality and fertility. The proportion of males reserved for breeding and reaching successful freezing stage was lowest (29%) in crossbred bulls and highest (45%) in indigenous cattle and poor semen quality was an important reason of disposal in crossbred bulls. Currently we do not have specific markers to predict bull fertility at younger age. However it is high time to initiate research to identify and develop suitable markers/tests so that the future fertility of the bull can be predicted at younger age thereby reducing the bull rearing cost.

One of the promising ways to produce many superior bulls is the use of multiple ovulation and embryo transfer (MOET) technology. Establishing bull mother farms and use of this technology will help in producing more number of bulls at a given time from elite dams. When used along with sexed semen, the outcome of
MOET would be very high. Several cutting edge developments have been made in embryo biotechnology research with tremendous progress in basic embryo transfer techniques, \textit{in-vitro} maturation of oocytes and \textit{in vitro} fertilization and production of buffalo calves by IVF technology. However their application at field levels is very limited. The reasons for the procrastination in application of use of embryo biotechnologies are a matter of serious concern.

\textbf{Milk processing and value addition}

Since India produces more milk in the region, the milk processing and value addition scenario is analyzed here based on Indian context. Although the white milk revolution was spearheaded in the country by the cooperatives, today just a little over 7\% of milk is handled by cooperatives. A large number of private sector companies/firms have been established in the country since liberalization of the dairy sector in 1991. Of the total milk produced, about 50\% is retained by producers for domestic consumption leaving about 50\% as marketable surplus. Milk processing in India is around 35\%, of which the organized dairy industry accounts for only 13\%, the remaining 22\% is processed in the unorganized sector. Of the milk traded, over 50\% of the milk is in the form of liquid milk, another around 35\% in the form of traditional products and the remaining 15\% is butter, milk powders and other western type manufactured products such as cheese, ice cream, infant milk foods, dairy whiteners, etc. The share of the total milk processing capacity by private sector is 61\% of total installed capacity as against only 36\% in cooperative sector. The total share of the organized sector, cooperatives, Government as well as the private sector is barely 13\% leaving remaining 87\% share of the total milk production in the hands of the unorganized sector. Given this situation in India and other regional countries where cooperatives are not well established and milk production and procurement is low, it is obvious that the milk processing situation would not be very encouraging.

The untapped potential of the dairy sector in in the region is immense and opportunity to set up new ventures for value addition is great. In order to meet the growing domestic as well as export demand, the dairy sector must increase its competitiveness in the global marketplace, by bringing about a qualitative transformation in the unorganized sector, which incidentally meets the entire demand for traditional dairy products, to ensure consumer safety. There is a need to upgrade the dairy value chain to eliminate inefficiencies and lower production and processing costs, while simultaneously increasing milk quality so as to meet domestic and international standards. The sector however faces a number of challenges that hinder this quest for competitiveness both in the local and global markets. The dairy industry must bridge the significant quality gaps that exist,
meet higher quality standards and seize market opportunities, while defending its domestic market from high-quality imports. Therefore, major transformations in dairy sector are anticipated to impart greater competitiveness and opportunities for value addition. The main areas need to be given due attention are as follows.

- Improvement in raw milk quality.
- Increased processing efficiencies with a reduction of environmental impact.
- Development of cost effective technologies for value addition.
- Promote strategies to control food borne illnesses.
- Development of functional foods that promote health and well being.
Chapter 11

QUALITY CONTROL IN THE TRADITIONAL AND COMMERCIAL DAIRY SECTORS

The future of the Dairy Sector has to be built on quality which can help access our dairy industry into a global market. For maintaining strategic advantage in the fast changing global trade scenario, it is imperative that stringent quality measures are followed in all stages of post-harvest handling of milk. International specifications of milk quality have to be complied with, which are necessary both from commercial and human health points of view. Under the new regulation of sanitary and phytosanitary (SPS) measures, microbiological quality control of the product is of great importance. It is not possible to produce good quality milk and milk products from poor quality raw milk.

A recent study conducted by FICCI (FICCI, 2010) revealed that quality of raw milk, cold chain infrastructure needed to maintain the quality of milk, conditions of transportation of milk. A large gap in terms of awareness and implementation of good dairy farming practices that are required to improve the quality of raw milk, facilities for testing the raw milk at the grass root level and the lack of skilled manpower are the major factors that impact the quality of the processed milk products vis-a-vis the prescribed standards. A positive attitude towards the implementation of good hygiene practices at the primary milk production level and translating these as good manufacturing practices (GMP) at the plant level should probably be the first steps to be taken for clean milk production.

Machine milking is now widely advocated for clean milk production. Adoption of machine milking, however, under small holder production system is difficult unless efforts are made to adopt Kolar model of Community Milking Centres in India, which was introduced to Kolar district in Karnataka State in 2001 and was the first in India. The centres represent new technology to be implemented at village level including bucket milking machines and cooling tanks. The system requires farmers to bring their dairy herd to the centre and milk the cows by machine. The milk is then directly cooled and stored at the centre thereby facilitating quality control. Research findings indicated a high level of satisfaction among all stakeholders with the Community Milking System. Besides substantial increase in milk quality and freshness, there is sociological improvements for the farmers, decrease in human effort, increase in freedom and flexibility especially for women and the enhancement of self-esteem among farmers. Replication of Kolar model of community milking in other villages would certainly bring about noticeable improvement in milk quality. Another interesting concept getting popular in parts of Kerala is the mobile Machine...
Milker. Machine is mounted on a motorbike, which facilitates easy movement between farms and at each farm hygienic milking is practiced. It is suitable for a group of farmers with 1-3 animals in cluster who can not afford individual milking machine. This system can conveniently milk 25-30 cows per session in a cluster. There is a scope of upgrading the system to a mobile milking van. A mobile milking van could be developed which can house a milking machine, milk weighing balance, fat/SNF tester and a bulk cooler. The van can be used to milk the animal, weigh and record the milk, analyse it for fat/SNF content to facilitate payment, and cool and store the milk in bulk cooler.

Post-milking improvement of milk quality is also equally important. There is a need to promote, prompt chilling and minimize/eliminate various pollutants and contaminants like pesticide residues, antibiotic drug, hormone, heavy metals, adulterants, etc. during processing and transportation. The Government of India launched a centrally sponsored scheme on strengthening infrastructure for quality and clean milk production (CMP) in October 2003, with the main objective of improving the quality of raw milk produced at the village level in the country. Under this scheme, assistance is provided for training of farmers on good milking practices. The scheme is being implemented on 100% grant-in-aid basis to District Coop Milk Unions and State Coop. Milk Federation through the State Governments/UTs for components viz., training of farmer member, detergents, stainless steel utensils, strengthening of existing laboratory facilities whereas 75% financial assistance is provided for setting up of milk chilling facilities at village level in the form of Bulk Milk Coolers. The scheme has benefited 5.3 lakh farmers by imparting training and by installing 21 lakh litre capacity of Bulk Milk Coolers to facilitate marketing of milk produced by them and keeping its quality intact.

The second intervention by the Government of India was introduction of Dairy Venture Capital Fund to support small scale milk producers in the non organised sector especially in the rural areas for the up-gradation of traditional technology to handle operations on a commercial scale using modern equipment and for the up-gradation of the quality of milk. Financial assistance is provided to small scale milk producers for the establishment of small dairy farms; purchase of milking machines/milk-o-tester/bulk coolers, etc; purchase of dairy processing equipment for manufacturing indigenous milk products; establishment of the cold chain facilities for milk and milk products; establishment of private veterinary clinics etc.

Codex guidelines stipulate that the raw material should be produced in a manner that minimizes bacterial load, growth and contamination. In post GATT era, the demand for quality dairy products necessitates dairy product manufacturers to adopt HACCP concept. In the recent past, the Indian dairy industry has taken
some positive steps in this direction, as some milk processing plants in the organized sector (cooperative and private) have adopted HACCP certification to ensure the quality of products.

The organized dairy industry follow adequate quality measures at milk collection point, which involves maintaining a record keeping system that documents each member/supplier, testing each batch received (no matter how small) and recording. The results by member, using multiple tests, such as cryoscopy and/or lactometer for adulteration, titratable acidity/COB/alcohol test for bacteria load, and mastitis detection, rejecting milk that falls below specified standards, and taking corrective action when a member repeatedly delivers milk below quality standards.
Chapter 12

DIVERSIFICATION OF DAIRY PRODUCTS BY TRADITIONAL AND NOVEL TECHNOLOGIES

Dairy industry could be sustainable only when remunerative prices to the farmer, value to the consumer, reasonable returns to the industry and stakeholders are ensured through efficient supply chain and value addition through product diversification. Driven by higher incomes and greater interest in nutrition, demand for dairy products in India is likely to grow significantly in the coming years, consumption of processed and packaged dairy products is increasing especially in urban areas. Growing automation in homes (cooking robots, microwave ovens) has necessitated new kind of dairy products. With the growing attention to the safety of dairy products, there is increased emphasis on quality above price. A spectacular increase in demand for convenience foods is being projected by marketing experts. Furthermore, an increased emphasis on the health aspects of foods and human slimness, fitness, strength and energy are already evident. In the cities, consumers are looking for newer dairy products with an extended shelf-life. All of these future trends indicate an enlargement of organised food marketing channels with a greater link with farmer co-operatives (Mathur, 2000).

In this age of liberalization and globalization, there is renewed focus on product diversification, value addition, quality improvement and export promotion. There are opportunities to diversify by modernizing the traditional dairy products sector, exploit the potentials of buffalo milk as well as to manufacture various convenience and functional dairy foods. Some of the developments are delineated below.

TRADITIONAL INDIGENOUS DAIRY PRODUCTS

Traditional Indigenous Dairy products have played a significant role in the economic, social, religious and nutritional well being of our people since time immemorial. It is estimated that about 50% of milk produced is converted by the traditional sector (halwais) into variety of Indian milk products, using processes such as heat and acid coagulation, heat desiccation, and fermentation. Of the total milk produced, 33% is used for the manufacture of ghee and makkhan, 7% for manufacture of dahi and other fermented milk products, 7% for partially desiccated milk products such as khoa and khoa based sweets and 4% of milk is used for manufacture of chhana based sweets and paneer. The market for Indian milk products as on 2011 is estimated to be of the order of Rs. 1550 billion. This fact underlines the significance of traditional dairy products in the national economy. In spite of such a great importance of traditional dairy products in the
region these products are still produced manually in the small sector with variable quality depending on the skill of the halwais. There is hardly any quality control and the shelf life is poor. The current methods of manufacture of these products are primitive and based on techniques that essentially remained unchanged over ages. The rural scale operations are associated with inefficient use of energy, poor hygiene and sanitation and non-uniform product quality. Most of the preparations are labour intensive and rely on local inputs. The marketing of these traditional dairy products is as traditional as are the products themselves. Halwais produce and sell these products in urban, semi-urban and rural areas. Very little attention is paid to packaging and sanitary handling practices. Most sales are across the counter and festival season accounts for almost 30-40 percent of annual sales.

Deep rooted tradition offer a considerable scope for organizing and channeling the amount of milk going for conversion into traditional dairy products. The major strength of the traditional dairy products sector is the mass appeal enjoyed by such a wide variety of products. The market for these products far exceeds that for western dairy products. Their operating margins are also much higher, mainly due to lower raw material cost. It is estimated that the raw material costs of shrikhand, rasogolla, gulabjamun, khoa sweets (peda, burfi, kalakand), sandesh and paneer is 29%, 33%, 34%, 35% and 65% of the sale price, respectively. For western dairy products, comparative costs are relatively much higher varying from 70-80%.

Increasing demand for these products present a great opportunity for the organized dairies in the region to modernize and scale-up the production. The expanding business prospects provided by these products and their accompanying value-addition call for a thorough revamping of this sector. Large-scale manufacture of these products in a hygienically safe manner with assured quality control and proper packaging will certainly do wonders for this sector in the region. A variety of traditional dairy products are produced in the region. Brief description of various Indigenous dairy products is given below:

**Heat desiccated products**

*Khoa*: It is a product obtained from cow, buffalo or mixed milk by heat desiccation of milk to 65-70 percent solids in an open pan. Also called khawa or mawa, it forms the base material for a variety of sweets such as burfi, kalakand, gulab jamun, peda, etc. and for stuffing in vegetable dishes. *Khoa* is classified into following three major kinds.

<table>
<thead>
<tr>
<th>Type</th>
<th>Fat (%)</th>
<th>Total solids (%)</th>
<th>Specific sweet prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pindi</td>
<td>21-26</td>
<td>67-69</td>
<td>Burfi, Peda</td>
</tr>
<tr>
<td>Dhap</td>
<td>20-23</td>
<td>56-63</td>
<td>Gulabjamun, Pantua</td>
</tr>
<tr>
<td>Danedar</td>
<td>20-25</td>
<td>60-65</td>
<td>Kalakand</td>
</tr>
</tbody>
</table>
**Kalakand:** A sweet made from danedar (granular) khoa having yellowish-white to light caramel colour with a granular texture and firm body. It is prepared by adding small quantity of citric acid solution during khoa-making process to permit the formation of well-defined grains.

**Burfi:** A khoa-based sweet having white to light cream colour with firm body and smooth to granular texture. It is manufactured by heating Khoa (usually pindi type) in an open pan over a low fire, adding sugar (25-35% of khoa) and mixing vigorously to dissolve sugar and form a smooth mass.

**Peda:** A khoa-based sweet having whitish yellow colour and a smooth but firm granular texture. It is generally prepared by mixing khoa and sugar in the ratio of 3:1. There are several variants of peda such as brown peda, which is characterized by caramelized color and highly cooked flavor and is popular in many parts of the country. Other popular variants are Mathura peda, Dharwad peda, kesar peda and Mishra peda. Kesar (saffron) peda is one of the preferred peda in which saffron is added for getting characteristic flavour and colour.

**Milk cake:** Milk cake is a khoa based sweet, which is very popular in northern and central parts of India. Milk cake is characterized by well defined grains with pronounced caramelized flavor which is comparatively more intense than kalakand. The milk cake has characteristic colour pattern, the central portion of the piece is more intensively brown and caramelized than the outer portion. The light portion of milk cake is yellowish white in colour with luster and dark portion is dark brown in colour with high luster. The milk cake has high degree of stickiness, gumminess, chewiness, graininess and moderate firmness.

**Gulabjamun:** A khoa based sweet, having a light to yellowish brown to dark brown colour, uniform, round/elongated or cylindrical shape, and smooth and glossy appearance. Gulabjamun has a typical heated fresh aroma, moderately sweet taste, free from doughy feel and fully saturated with syrup. It has soft and thin crust, smooth but firm granular texture, soft and spongy body which is free from lumps and hard central core. It is generally served warm as a dessert. Gulabjamun is popular in northern, western and central regions of India.

**Kunda:** Kunda is defined as a desiccated product prepared by the continuous heating of milk or high moisture khoa with sugar. It is characterized by semi-brown to brown colour, soft body and grainy texture, and characteristic sweet, nutty and pleasant flavour.

**Khoa-jalebi:** On occasions like feast, people of certain regions in central India prefer to eat khoa-jalebi which is made from khoa and arrowroot powder and is devoid of maida. Khoa-jalebi is popular in Nagpur and Nasik regions in Maharashtra. It is also popular in areas like Raipur, Indore and some parts of southern Rajasthan. The khoa-jalebi has round to irregular shape with two to four coils, resembling the traditional maida-jalebi. The colour is dark brown to very
dark brown with light and dark shades appearing on surface in many pieces. The khoa-jalebi pieces have slight moist appearance because of coating of sugar syrup. The insides of the sweet are lighter and softer as compared to the crust. The texture of the khoa-jalebi is firm and slightly juicy. Syrup oozes out when it is chewed but to a lesser extent than the traditional maida-jalebi.

**Concentrated products**

*Basundi:* An indigenous milk product having appearance like condensed milk with soft flakes. It has a pleasant, condensed milk like flavour with cooked and caramel flavour notes that is relished.

*Khurchan:* A concentrated, sweetened whole milk product, which is quite popular in North India. It is normally prepared by heating 3-4 kg milk in a shallow pan and allowing it to simmer, with controlled heating till the volume of milk gets reduced by evaporation of water to about one-fourth of the original, good quality ground sugar is added to the concentrated mass at 5-6 percent by weight of the original milk and dissolved in it. The finished product has a slightly cooked flavour, which is relished.

*Rabri:* A concentrated and sweetened whole milk product containing several layers of clotted cream. Rabri is normally prepared by heating 3-4 kg of milk in a shallow pan over an open fire and allowing it to simmer until the slow evaporation reduces the milk to about one-fifth of its original volume, good quality ground sugar is added to the milk concentrate at the rate of 5-6 per cent by weight of the original milk and dissolved in it. The finished product consists of non-homogeneous flakes partly covered by and partly floating in sweetened condensed milk.

**Acid and heat coagulated products**

*Paneer:* Paneer, a highly popular product throughout the region, has many uses starting from its consumption in raw form to preparation of several varieties of culinary dishes and snacks. Since it is a high protein food, this cheese is often substituted for meat. Good quality paneer is characterized by a white color, sweetish, mildly acidic, nutty flavor, spongy body and close knit texture. Buffalo milk is preferred for manufacture of paneer as it has all these attributes.

*Chhana:* Chhana is a base material used for preparing many kinds of sweets such as rasogolla, sandesh, etc. Chhana from cow milk is light yellow in colour, has a moist surface, soft body and smooth texture whereas that from buffalo milk is whitish in colour. Both have a pleasant, sweetish mildly acidic flavour.

*Rasagolla:* Rasagollas are in the form of small round balls (~30 mm in dia.) with a typical sponge body and smooth texture, and snow-white in colour. A large, yellowish and somewhat less soft variety of rasagolla is called rajbhog. Rasogolla are stored and served in sugar syrup.
Rasmalai: A chhana based sweet with extremely delicate texture and flavour. It is popular in most the SAARC member countries. The product contains flattened chhana balls cooked in 60% sugar syrup for 20 minutes and then dipped in condensed milk (to one fourth of its original volume by heating) with added sugar (5-6% of the original volume of milk).

Sandesh: A chhana-based sweet, having firm body and a smooth texture. Sandesh is classified broadly into three types, viz. karapak (low moisture), narampak (medium moisture) and kachhagolla (high moisture). Among these narampak is the most popular variety. Another type of sandesh, known as Nalin sandesh, is prepared from date gur (date jaggery) between November and February, when dates are available aplenty. Nalin sandesh is considered a delicacy and commands a much higher price.

Chhana kheer: It is prepared by simmering milk on medium heat to which small cubes of chhana is added at 6 percent level. The mixture is simmered till desired concentration is achieved (~2:1).

Chhana-murkì: This sweet is in form of small cubes coated with sugar and has a fine body and a close-knit texture.

Chhana Podo: Chhana podo is unique as it is the only milk based indigenous dairy product prepared by baking chhana. It is characterized by a brown crust with a white or light brown inner body. It has a typical cooked flavour and rich taste. The product is sweetish due to the addition of sugar. It has a moderately spongy cake-like texture and soft body. Estimated annual production of chhana podo is approximately 1000 tons. Chhana jhili: A chhana based deep fried sweet product from Orissa in India. It is characterized by irregular shape, golden to dark brown colour, soft body and spongy texture with rich caramelized cooked flavor.

Chhana pulao: A sweet similar to chhana murkì in which chhana is shaped into rice-like grains and coloured golden.

Chumchum: Chhana based sweet coated with sugar or khoa which has a firm body, a close-knit texture.

Khirmohan: Khirmohan is a popular sweet and is preferred for its texture and taste.

Lalmohan: A chhana based product similar to gulabjamun but lighter in colour than gulabjamun.

Pantua: A chhana based product similar to gulabjamun. It is very popular in Eastern India. It is prepared by mixing chhana (2 parts) with khoa (1 part).

Bandel (Bandal) cheese: An indigenous, unripened, salted, and soft variety of cheese. This type of cheese was available in and around Bandel, a Portuguese colony in eastern India, and seems to have derived its name from it. Bandel
cheese is similar to *Surti* cheese. A similar variety of cheese available in the eastern region is Dacca cheese. It differs from *Bandel* cheese in that the cakes formed by flattening, after removal from the perforated pots, are further smoked in a smoky fire. *Bandel* is highly aromatic.  

**Durukho:** Milk solids produced by boiling buttermilk (*mahī*) are wrapped in a cloth and pressed under stones. When all the whey is driven out, the resulting mass is cut into one-inch cubes and dried in the sun. People like to chew the dry *durukho* when climbing in the Himalayas. It is also produced from partly skimmed milk.  

**Kradi:** Also referred as milk bread, is a famous traditional milk product of Jammu and Kashmir. *Kradi* is a heat and acid coagulated dairy product. It has two more synonymous names viz. *maush kraer* (maush in Kashmiri language means buffalo, therefore, maush kraer means *kradi* made of buffalo milk) in Srinagar and *kalari* in the upper hilly regions of Jammu division of Jammu and Kashmir but the product is identified and familiar with *kradi* name. It is a type of fresh unripened cheese made by heat coagulation of buffalo milk with some easily accessible coagulating agent like *lassi* (sour buttermilk) and working out the coagulum into a pat.  

**Sherghum:** It is a Nepalese cottage cheese prepared from Yak and Chauri milk. *Sherghum* is a product made from precipitated proteins from buttermilk heated up to boiling point. The separated curd is either freshly used as such or sundried and ground in powder to be stored. Fresh *sherghum* has a mild and slightly acid taste. *Sherghum* powder has light green colour. *Sherghum* is used in cooking of traditional Tibetan or Sherpa dishes. The powder is mixed with flour, butter and sugar to prepare a typical dish called “Satoo”.  

**Shosim:** *Shosim* or *Samar* is a product popular in high mountainous alpine regions of Nepal. It is a soft cheese overripe without rind. It has a very soft, greenish body with a close texture. It has a sharp and slightly acid taste when it is consumed after few weeks of fermentation only. It is obtained by fermentation of *sherghum* in anaerobic conditions, in a previously used wooden or earthen vessel containing non-descriptive type of micro-organisms for a long period of time (for at least 2 to 8 months). The fermentation is carried out in an air-tight vessel. The product is consumed in the form of soups.  

**Churpi:** This fermented cow's milk product is commonly used by the Tibetans inhabiting this region. Two different kinds of *churpi*, soft and hard, are available. The soft type is prepared in both hilly and terai areas (the plain land of the Darjeeling district which is at the foot of the hills) and the hard type is restricted to the high altitudes (1300-4000 m) of the Darjeeling district and North and East Sikkim. The *churpi* is consumed as a condiment by mixing with sliced radish or cucumber; it is also mixed with meats, vegetables and spices to prepare
curry. Hard churpi (‘churpi’ to the Nepalis; ‘chura’ to the Sikkimese; ‘khamum’ to the Lepchas) prepared by sun drying of churpi for 2-3 weeks. This type of churpi becomes very hard and, having low moisture content, can be stored for a number of years. Churpi is sweet in taste and is used in much the same way as chewing gum. Chura, a kind of cheese similar to hard churpi, has been reported to be commonplace in Tibet, Nepal and north-east India.

Dudh churpi: A popular traditional milk product in several countries of the Indian subcontinent. It is prepared by acid-and-heat coagulation of partially defatted (made by using a bamboo churn) milk of yak, dzno (a crossbreed of male yak and cow) and cow in Bhutan, Sikkim and Darjeeling, respectively. The green curd is cooked in an open pan until the disappearance of free moisture. The hot cooked curd is wrapped in a hessian cloth, pressed heavily under stone overnight, cut into pieces, made into a ring with a cotton thread and dried over the warmth of a wood fire for 5–7 days. The partially dried product (prechurpi) is cooked in concentrated milk-sugar solution. Dudh churpi is sold as rectangular pieces having a creamy to chalky white surface, moderately sweet and smoky with a hard and compact body. The product is consumed by biting or chewing, like betal nut or chewing gum.

Fermented dairy products

Dahi: A yougurt-like product made from cow, buffalo or mixed milk, it is widely consumed all over the region, as plain, sugared or salted dahi. It is taken as part of the meal, sometimes lightly salted and spiced with grounded red pepper and roasted cumin seed powder or stirred with finely chopped or ground mint, spinach or balhua leaves, or boondi. Dahi is a base for making raita, lassi, kadhi, chakka, shrikhand and makkhan. Dahi has a mild pleasant flavour and a clean acid taste. It has a yellowish creamy-white colour when made from cow milk, and a creamy white colour when made from buffalo milk with a smooth and glossy surface. The body is soft and firm, free from gas holes.

Chakka: An intermediate product in the process of manufacture of shrikhand. It is obtained by hanging dahi in a muslin cloth for 6-8 hours to drain off whey and to produce a solid mass called chakka or maska.

Lassi: A refreshing beverage having whitish, viscous fluid with creamy sweetish, rich aroma and mildly to highly acidic taste. It is prepared by stirring dahi and adding a small quantity of cold water. It can be flavored in various ways with salt, mint, cumin, sugar, fruit or fruit juice and even spicy additions such as ground chilies, fresh ginger or garlic.

Chhach: A bye product obtained after churning of dahi and skimming off the makkhan is known as chhach, chhaas or mattha. It is used for direct consumption after addition of salt and roasted cumin seed powder (jeera) or used for making kadhi.
Kadhi: Kadhi is made from chhach (buttermilk). It is prepared by mixing small amount of Bengal gram flour (besan) to appropriate quantity of chhach, adding small quantity of spice mix (salt, black pepper, green chilly, turmeric, coconut, ground cumin, curry leaves, etc.) and bringing the mixture to boil with constant stirring. It is generally served hot with rice. In some regions, bhajia (small balls made out of besan dough and fried in oil) are added to kadhi and served as a curry.

Mishti doi: A sweet variety of dahi, which is popular in Eastern India. The product is also known as lal doi (red dahi) or payodhi. It has a typical light brown colour, a cooked and caramelized flavour and a firm body.

High fat dairy products
Malai: It is the firm skin that forms at the surface on cooling the boiled milk. It is skimmed off and used with bread or fermented with dahi culture and converted into ghee.

Makkhan: Traditional unsalted butter made by hand churning whole milk dahi in an earthen pot at room temperature using indigenous wooden churning devices. Makkhan is hand scooped or removed with a wooden ladle or a perforated scoop and not usually washed. It can be compared to ripened cream butter. Buffalo milk makkhan has a harder/finer body and a more granular texture than that from cow milk. It has a pleasant, mildly acidic flavour.

Ghee: A product exclusively obtained from milk, cream or butter, by means of processes which result in almost total removal of water and non-fat solids, with an especially developed flavour and physical structure. Ghee originated in India much before recorded history and the name originates from the Sanskrit word meaning "bright". The Vedas contain numerous references to ghee. The colour of cow ghee is deep yellow while that of buffalo ghee is white with a characteristic yellowish or greenish tinge. Ghee has a pleasant cooked and rich flavour.

Frozen dairy products
Kulfi: Kulfi is the indigenous ice cream frozen in small containers. It is usually consumed in summer and also called malai kulfi. Kulfi has a milky appearance, but additional colors may be applied for increasing appeal. It comes in variety of flavors such as mango, kesar or cardamom. It is typically sold by street-side hawkers called "kulfiwalla" who carry around these frozen cans of kulfi in a big earthen pot.

Milk-cereal/ pulse based products
Kheer: It is a heat-desiccated, cereal-based sweetened and concentrated milk confection and has a thick consistency resembling to rice pudding. Kheer is preferably prepared from buffalo milk as it is whiter and thick bodied than cow
milk. A process of long-life kheer has been developed by adopting in-package cooking and sterilization of kheer in retort pouches.

Payasam: There are several varieties of payasam with distinct characteristics that may be attributed to the area of their origin and traditional methods of preparation. These include vermicelli payasam, khuskhus or gasa-gase (poppy seed) payasam, palada payasam etc. The colour of payasam varies from white, light cream, cream and light brown to brown. The dry mixes of different varieties of payasam have been standardized and are available in the market.

Halvasan: Halvasan is milk based sweet traditionally prepared and originated in Khambat/Cambay, an ancient sea port of Gujarat. It is heat desiccated milk based sweet prepared from mixture of milk and sprouted wheat fada (pieces). It is sweetened and after desiccation and richly coloured, flavoured and decorated using nutmeg, cardamom, pistachio and saffron. Halvasan is having dark brown to brownish yellow colour. It is having grainy but compact texture which is sticky but not gummy and yet slightly chewy in nature. It is sweet in taste. It has rich flavour of saffron and cardamom with aftertaste of nutmeg.

In the high mountains of Nepal and Bhutan, yaks and chauries are the main source of income. Diversification by producing varieties of milk products from yak/Chauri milk is very essential to generate sustainable income. Yak milk is traditionally processed into fermented milk, and then churned out to produce local yak butter and buttermilk. Buttermilk is further processed into sher, a cottage cheese type product. If fermented, produces sewsew, and if pressed and dried or dried without pressing it becomes Chhurpi, a dried hard casein product. Chhurpi is widely consumed by Himalayan people as a source of nutrients, and is chewed to maintain salivation during mountain climbing. Khoa and chhana making in Nepal and India is mostly in or near town and cities. Hard Swiss Gruyere type cheese is also produced from yak milk. This cheese is popularly known and marketed by the name of Yak Cheese today. In Nepal the statistics of the production of khoa, chhana, chhurpi and sher or shergum are not available (Thapa, 1997).

To promote diversification of milk products, there is a need to upgrade and standardise the indigenous technology so as to commercialise these products. The already established technology like Yak Cheese could be exploited to a higher level of production with proper packaging and branding for targeting the export market.

Mechanization in manufacture of traditional dairy products

In order to overcome the inherent disadvantages associated with conventional methods of manufacture of traditional dairy products such as inefficient use of energy, poor hygiene and sanitation, non-uniform product quality, fatigue on the
operator, etc; attempts have been made to develop batch, semi-continuous, and continuous equipments for the manufacture of these products. Successful attempts have also been made to mechanize the methods of manufacture of khoa based sweets. Mechanized manufacture of burfi involving khoa-making by continuous machine followed by kneading and heating khoa-sugar mixture in Stephen kettle has been standardized by National Dairy Research Institute (NDRI), Karnal, India. The Sagar Dairy, Baroda manufactures kesar peda by adopting a large-scale mechanized process which involves manufacture of khoa using continuous machine, heating khoa -sugar mixture in planetary mixer, cooling, mechanical forming of peda and packaging. Similarly, gulabjamuns are being manufactured commercially using khoa portioning and ball forming machines followed by deep fat frying and sugar syrup soaking lines.

A prototype continuous chhana making machine for the mechanized production of chhana has been developed at IIT, Kharagpur, which involves indirect heating of milk in a tubular heat exchanger to 95°C, cooling to 70 °C, continuous coagulation with hot citric acid (70°C) in a vertical tube, holding milk-acid mixture to permit complete coagulation, separation of whey in a continuous flow employing double wall basket centrifuge and chilling to 4° C by directly spraying chilled water on the layer of chhana. A prototype machine for continuous manufacture of paneer has been developed recently at NDRI.

Developments have also been made in mechanization of chhana-based sweets. A prototype machine for continuous manufacture of rasogolla has recently been developed at NDRI, Karnal, which involves kneading of chhana using screw conveyor, portioning chhana into lump of 10 g each with a cutting device, and ball formation in a revolving cylinder, followed by cooking in sugar syrup. A single screw vented extruder has also been developed for continuous production of sandesh.

A fully mechanized/continuous process has also been developed for industrial production of shrikhand. In this process, chakka is prepared by separating the whey from skim milk dahi employing 28” dia. basket centrifuge at 1100 rpm. The resultant chakka, sugar and plastic cream are then mixed in a planetary mixer.

**Developments in packaging**

The traditional dairy products have been conventionally packaged in dhak leaves, paper cartons, polyethylene bags or cardboard boxes. These traditional packages do not provide sufficient protection to the product from atmospheric contamination and also do not have the functional properties in order to preserve the initial quality of the product for a longer time. As a result, the products soon loose their typical body and texture, pick up foreign odors, become
rancid/oxidized and give undesirable appearance. These packages are also not suitable for far-off transportation and outstation retail sales.

Recently, with the rapid developments in packaging technology, substantial progress has been made in packaging of traditional dairy products. Packaging of khoa in laminates of paper/aluminum foil/LDPE (55-60 gsm, 0.02 mm and 159 gauge), and Polycel (300, 150 gauge poly, colored) have been found to be quite satisfactory for khoa. In these packages, khoa can remain in good condition for 10 days at ambient temperatures and 60 days under refrigeration conditions. However, by using 4-ply laminated pouches made of PP/LDPE/Foil/LDPE, the shelf life of khoa can be increased to 14 days at 30°C and 75 days in cold storage. For packaging of chhana, polycel (300 and 150 gauge, colored) is good, low-cost packaging material.

Ghee is generally packaged in lacquered or unlacquered tin cans of various capacities ranging from 250g to 5 kg for retail sale and 15 lit for bulk sale. Some dairies pack ghee in polyethylene bags. Other recommended packages for packaging of ghee are polyester coated cellophane, polyester, nylon-6, food grade PVC or their laminates.

Recently, systems have been developed for assembly line packaging for shrikhand, dahi, misti doi, paneer, etc. and are being used in organized sector. Polystyrene or polypropylene tubs used for packaging of paneer extend shelf life of 180 days at -18°C and 30 days at 5°C. Rasogolla are being packed in lacquered tins with a shelf life of 6 months at room temperature. Polypropylene trays covered with transparent, coloured MXXT are recommended packages of burfi, peda and kalakand. Low weight, leak-proof lacquered kulhers for packaging dahi, misti doi, etc. have been developed at NDRI, which give better shelf life than plastic cups.

**Convenience traditional dairy products**

The changing life-styles and increased purchasing power especially among urban population has necessitated the research efforts for formulating ready-to use traditional milk products with added convenience, enhanced shelf life, added nutritive value, and with attractive packaging. Recently, number of such convenience products viz. khoa powder, kulfi mix, gulabjamun mix, rasogolla mix, burfi mix, chhana powder, instant rice Kheer mix, Makhana kheer mix, Shrikhand powder, Lassi powder, dried carrot milk food mix, ready-to-eat paneer curry, chakka powder, kadhi mix, palada mix, rasmali mix, basundi mix, paneer curry mix, etc. have been developed at NDRI and elsewhere, some of which are already being manufactured commercially.
UHT MILK

Various impediments faced in maintenance of cold chain i.e., maintaining the temperature of milk at 4°C from the time milk leaves the udder of the animal to the point of utilization at the consumer's end is very critical in regard to the quality and shelf life of pasteurized milk. However, insurmountable difficulties have been encountered in the Indian context for maintenance of cold chain due to several techno-economic factors under the tropical climatic conditions. Furthermore, there is a worldwide concern for conservation of energy in processing and distribution of foods. All these factors have led the planners to opt for UHT processing for market milk distribution.

UHT milk market size in India currently stands at 7 LLPD (lakh litres per day). National brands like AMUL, Nestle, Britannia and major regional players like KMF dominate this market. UHT Milk is available in Tetra Brick Aseptic (TBA) 1L packages and Tetra Fino Aseptic (TFA) 500ml packages. UHT Milk is growing at a CAGR of 34% in India. South India is leading from the front with CAGR of 50%. The market size of UHT milk in South India is currently 2.5 LLPD with TFA 500ml being the key growth driver. Major players in South India are KMF and Visakha with their brands ‘Goodlife’ and ‘GoodMilk’. In South India UHT Milk is available in TBA 1L, TFA 500ml and TFA 200ml. Of these three, TFA 500ml has 90% category share. IMARC Group, one of the world’s leading research and advisory firms, expects the Indian UHT milk market to more than triple its current size during 2010-11 and 2016-17. Certain marketing innovations such as UHT gift packs, the concept of premiumization and deeper penetration in tier 2 and tier 3 cities in India will create a true foundation for UHT growth in the country. Moreover, the advent of a wide range of processes capable of producing even viscous and particulate UHT products offers the dairy industry a great opportunity to expand its market base. The engineering and technological advances made in the recent past can be of considerable help in extending the long life benefits from fluid milk to other products like concentrate, cream, desserts, kheer, etc. With this the Indian dairy Industry now engaged in product diversification, value addition and export promotion.

DIVERSIFICATION THROUGH FUNCTIONAL/HEALTH FOODS

In recent years, there has been a shift in taste and preferences of consumers. They have become more health conscious and quality conscious. With an increase in life expectancy, the proportion of older people in the population will increase, and this could emphasize a demand for special nutritional products. Therefore, the dairy industry that is processing milk will have to stand up to the expectations of the market and consumers. The milk processors will have to bring in new insights to understand the customers, and bring out new and more customer-friendly products at reasonable costs while improving quality.
SAARC member countries present the biggest long-term opportunity for manufacture and marketing of functional foods. Population growth, rising incomes, increasing awareness on health, urbanization, lifestyle changes ("on-the-go" eating) and growing organized retailing are contributing to the potential for functional foods. Just as for processed foods in general, India will be the largest potential markets for functional foods with their GDP growth, demographics and burgeoning consumption (with over 50% in food spend).

Nutraceuticals are among the New Age drugs that are being developed to provide better health. The nutraceuticals or the functional foods are majorly plant-based products and most of them being predominantly herbal. Hence clues to these nutraceutical products have been received from Indian ancient and traditional systems of medicine like Ayurveda, Siddha and Unani. The 'Rasayan' and 'Vajikarna' therapeutics of Ayurveda are essentially nutraceuticals, and therefore, there is ample scope for India to develop a range of nutraceutical/health food products. The nutraceutical market in India is growing at a CAGR of 18.46 per cent and is expected to be worth Rs 19,500 crore (US$ 3 billion) by the end of 2013-14.

With the evolution of novel technologies and scientific developments in the past years, an increasing number of potential nutritional products with medical and health benefits have gained an important place in the world market. These “Functional foods” are expected to perform functions such as enhancement of the biological defense mechanisms, prevention/recovery from a specific disease, control of physical and mental conditions, slowing the aging process. Foods can be modified by the addition of phytochemicals, bioactive peptides, omega-3 PUFA and probiotics and/or prebiotics to become functional. Many of the dairy ingredients are also being positioned as potential nutritional products for incorporation in functional foods. Peptides derived from casein have bioactive properties. Whey proteins have also demonstrated physiological properties. Many of the functions of whey proteins are related to the immune or digestive system. Minor whey proteins such as lactoferrin, lactoperoxidase, lysozyme and immunoglobulins are effective antimicrobial agents. Lactoferrin exhibits both bacteriostatic and bactericidal activity against a host of pathogenic bacteria and yeasts. Lactose is known to enhance calcium absorption and its hydrolysis products lactulose and galacto-oligosacharides are being promoted as prebiotic growth promoters. These fractions of milk components offer tremendous scope for value addition. Potential for producing healthful functional foods incorporating valuable dairy and non-dairy ingredients in existing and new product formulations, therefore, need to be exploited.

Some useful studies have been carried out in India on development of functional foods. Several functional dairy foods viz., Arjuna herbal ghee, low cholesterol
ghee, functional long life paneer, functional *doda burfi*, vitamin fortified milk, calcium and iron fortified milk have been developed; some of which are being manufactured and marketed by Indian dairy industry.

Dairy foods are also excellent carriers of probiotics. Probiotic dairy foods containing health-promoting bacteria are an important segment of the functional food market. A variety of health benefits have been attributed to specific strains of lactic acid bacteria (*Lactobaillus* and *Bifidobacterium* spp.) or foods containing these probiotic cultures. Potential benefits include alleviation of symptoms of lactose mal-digestion, shortened duration of antibiotic associated diarrhea, maintenance of a healthy intestinal flora, decreased risk of cancer and heart disease and stimulation of host immune response. Several probiotic products such as probiotic dahi/lassi, probiotic Edam cheese, probiotic ice cream, etc. have also been developed in India.

**Dairy Based Dietetic Sweets**

In recent years due to the fast pace of life with increased mental stress and poor immune system and many more have contributed much towards the risk of diseases and made all the segments alert, to consume less calories in the form of sugar based confections such as sweet and desserts. This scenario of alertness gave manufacturers an idea to diversify the production and to include the specialty items that cater to specific targeted populations and led towards dietetics. Diabetic-friendly traditional sweet is an example of such category, the production of which is being contemplated by many enterprising manufacturers.

Excess sugar consumption interferes with the body's absorption of minerals (calcium and magnesium), raises cholesterol levels, and causes allergies, kidney damage, high blood pressure, and a host of other problems. This knowledge has led to the concept of artificial sweeteners. Aspartame, Alitame, Saccharine, Neotame, Acesulfame-K, Sucralose, cyclamates and many more comes under the category of artificial sweeteners in the sense that they do not impart any or little calories and passes the human system without getting metabolized. Hence, also referred as “non-nutritive sweeteners”, high intensity, or high potency sweeteners because only a small part is needed to achieve the same sweetness as provided by a large amount of sugar. According to the Prevention of Food Adulteration (PFA) Rules 1955, the Ministry of Health and Family Welfare, Govt. of India on June 25, 2004, the use of artificial sweeteners has been permitted in food items as per the limits prescribed and under proper label declarations.

Various products have been formulated using high-intensity low-calorie sweeteners such as saccharin, acesulfame-K, sucralose and aspartame were used
as replacers for sucrose in the manufacture of *burfi*. *Burfi* sweetened with low-calorie sweeteners though ranked lower but was still acceptable in various textural attributes at all periods of storage in comparison to the control (prepared with sucrose). Successful use of low calorie sweeteners in the preparation of *burfi* and Kalakand with a slight difference in its overall acceptability has been attempted (Arora et al., 2007, Arora et al., 2008). Different authors prepared *burfi* using different artificial sweeteners by completely or partly replacing sugar. Acesulfame-K was used by Yarrakula (2006), Aspartame (Muralidhar, 2006), saccharin (Narendra, 2006), sucralose (Singh, 2006), and various sweeteners individually as well as in combination along with various bulking agents were used by Prabha (2006). Though results were similar with minor differences among them, but blend of sweeteners was found acceptable in terms of sensorial, and its cost effectiveness.

Chetana et al., (2004) had developed *gulabjamun*, a popular *khoa* based sweet, using sorbitol. The Indian counterpart for ice-cream, *kulfi* had been developed by Pandit (2004) formulated *kulfi* with artificial sweeteners using 4.26% maltodextrin, 5.51% sorbitol and 741.9 ppm aspartame. Study revealed that maltodextrin and sorbitol was necessary to get desirable body and texture in the final product whereas the level of aspartame majorly affected sweetness of the product. The product was found to be sensory acceptable. Various other dietetic dairy products using natural sweetener Stevia have been formulated (Salem and Massoud, 2003).

Jayaprakash (2003) developed rasogolla with artificial sweeteners with the use of 41.77% sorbitol and 0.08% aspartame. Product had desirable shape, softness and porosity. Aspartame did not affect the sensory quality of the product except its sweetness. Singh and Jha (2005) investigated the effect of sugar replacers on sensory attributes and storage stability of *Shrikhand* and observed that raftilose when used @ 4% along with 12.5% sugar resulted in acceptable product with good flavour and overall acceptability.

With the increasing awareness and importance of fiber rich diets in human nutrition, dietary changes has led pathway towards fiber incorporation. In India, some traditional dairy products are manufactured that contain significant quantities of fiber e.g., *Gajarella* (carrot milk cake), *Giya-ka-halwa* (bottle gourd halwa), *Doda-burfi*, and *Kaju-burfi*. Some cereal based puddings or desserts like *kheer, payasam* and *dalia* are other dairy food sources of dietary fiber in Indian diets (Patel and Arora, 2005). *Burfi, Pinni* and *Sevian*, Indian dessert were prepared using cereal supplemented with germinated wheat flour were reported to be a good source of fiber (Reema et al., 2004). Attempts have been made to enrich kheer and paneer with dietary fibre.
HARNESSING BUFFALO MILK ADVANTAGE FOR DIVERSIFICATION

At global level, the contribution of buffalo towards the total milk production is only 12.8% but in SAARC member countries, buffaloes are contributing about 52% of the total milk produced, therefore can be considered as main species for milk production. Buffaloes appear to have equally or even surpassed the cattle in growth, environmental tolerance, health, milk, and meat production. Buffaloes have been found to thrive on coarse fodders and better converter of feeds into milk. Buffalo milk has a number of qualities that make it more favourable as compared to cow milk. Truly speaking, buffalo milk is richer than cow milk in most of the constituents and is preferentially used for the manufacture of variety of products that has achieved worldwide acceptance. Buffaloes are, therefore, considered as an added advantage to India when compared with bovine wealth of the other dairying countries. In essence, buffalo can be considered as a symbol of Asian life and endurance.

About two decades ago it was felt that buffalo milk was probably not suitable for the manufacture of western milk products. However, several meaningful technological processes have now been developed to manufacture these products from buffalo milk. Today, dairying in India has become an instrument for rural development in improving the economic status of the small farmers and most of this milk is coming from the buffaloes.

Compositional Advantages

The composition of cow and buffalo milk has been a subject for research works in several countries all around the world. However, it must be outlined from the beginning that cow milk has been studied, much more than buffalo milk, due to the fact that, it shows greater commercial interest in developed countries. In contrast information on buffalo milk is comparatively less, but at the same time, enough to permit a satisfactory comparison between the two kinds of milk. The average composition of the buffalo and cow milk given in Table 6, reveal that buffalo milk is significantly richer in fat, protein, ash, lactose and total solids than cow milk. It is remarkable that the ratio between fat/protein is significantly higher in buffalo milk than in cow milk. These of course, bring along differences in the nutritive value of the two kinds of milk. When used for making any product, it is obvious to obtain considerable higher yield from buffalo milk, a fact of particular significance because this milk is used almost exclusively for all indigenous dairy products in India.
Table 6: Gross chemical composition of cow and buffalo milk*

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Concentration (%)</th>
<th>Buffalo milk*</th>
<th>Cow milk**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids</td>
<td>16.3-17.0</td>
<td>13.7-13.8</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>6.6-8.8</td>
<td>3.6-4.9</td>
<td></td>
</tr>
<tr>
<td>Proteins</td>
<td>3.9-4.22</td>
<td>3.3-3.4</td>
<td></td>
</tr>
<tr>
<td>Lactose</td>
<td>4.5-5.2</td>
<td>4.1-4.5</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>0.70-0.80</td>
<td>0.70-.73</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>0.18</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.02</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>0.04</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>0.11</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>0.07</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Ca/P ratio</td>
<td>1.80</td>
<td>1.20</td>
<td></td>
</tr>
</tbody>
</table>

* Sindhu (1995) and Mathur et al. (1999).

The total concentration of glycerides in buffalo milk is higher than in cow milk, which is due to higher fat content in the former, but their proportions are similar in both milk. The level of fat variations is markedly higher in buffalo milk than those for cow milk. Buffalo milk fat is richer in butyric acid and long chain saturated fatty acids viz. palmitic and stearic acids and has lower content of C6 to C12 fatty acids. Buffalo milk fat is more polar in nature as compared to cow milk fat, which contributes better emulsifying property to it. This aspect has not received any attention yet. Moreover, there is a wide difference in the content of polyunsaturated fatty acids in buffalo versus cow milk fat. The phospholipid content of buffalo milk fat (21 mg %) is lower than (32 mg %) in cow milk fat, thus buffalo butter and ghee are poor in phospholipids (Kuchroo and Narayanan, 1977). Phospholipids of buffalo milk fat show a definite antioxidant action due to higher content of cephalin, which is known to be a potent antioxidant (Thakur, 1968). Similarly, free fatty acid content of buffalo milk and ghee was reported to be significantly lower than in cow milk and ghee (Sharma and Bindal, 1987). The minor fat components of buffalo milk fat like squalene and ubiquinone (8.29 and 6.51 μg/g, respectively) are higher than (5.92 and 5.03 μg/g, respectively) in cow milk fat.
The protein profile of buffalo milk and cow milk includes casein (2.88-3.24, 2.54-2.59%) and whey proteins (0.74, 0.52%), respectively (Ghosh and Anantkrishnan, 1965). Proportion of micellar casein was more in buffalo milk whereas soluble casein was very low. Further, the calcium content of the micelle was distinctly more (3.5%) compared to cow casein micelle (2.8%). Phosphorus content was also similarly high in buffalo casein micelle. Voluminosity of cow milk casein micelles (2.80-3.28 ml/g) is slightly higher than (2.68 ml/g) that of buffalo casein micelles (Kuchroo and Malik, 1976). Besides the proteose-peptone content of buffalo milk (190 mg %) was less than that of cow milk (230 mg %). The lactoferrin content of buffalo milk is 32 mg%, which is much higher than (7-15 mg %) that of cow milk (Valsa, 1977) and the iron content and iron saturation respectively of milk lactoferrin are 1.1 mg/g and 77% in cows and 1.5 mg/g and 104% in buffaloes (Mahfouz et al., 1997).

From the aspect of enzymes also, the buffalo milk has certain advantages. Although milk enzymes do not contribute to the nutritional well-being of young ones, sometimes cause problem during the storage of milk and milk products. The lipase and alkaline phosphatase activities are lower in buffalo milk, about two-third of the cow milk enzyme. Further, the higher stability of xanthine oxidase that is considered to be responsible for oxidative degradation in Domiati cheese pose less problems when made from buffalo milk as the activity of this enzyme is significantly lower in buffalo milk (45.74 mU/ml) as compared to (70.29 mU/ml) in cow milk (El-Gazzar et a.,1999). In addition, the buffalo milk differs from cow milk in terms of slightly higher protease activity, lower lysozyme and $\gamma$-glutataryl transpeptidase enzymes content. Besides, the ribonuclease enzyme, which is associated with the stability of fat emulsion, is present in higher concentration in buffalo milk.

**Benefits from physical properties**

Buffalo milk has certain inherent advantages compared to cow milk due to the difference in the physical properties of the two milks (Table 7). The lower heat capacity, higher thermal conductivity and expansion of buffalo milk clearly indicate that definitely slow and a lower quantum of heat energy is required for its concentration to achieve certain desired heat effects. Creaming in buffalo milk is slower and a higher temperature than that used for cow milk is beneficial. The lack of agglutinin complex is supposed to be the reason for slow creaming in buffalo milk (Gonzalez Janolino, 1968). Laxminarayanan and Dastur (1968) reported that buffalo milk has comparatively bigger fat globules (average 5.01 $\mu$m) as compared to cow milk (average 3.85 $\mu$m). The buffalo milk fat is also markedly different in its physico-chemical characteristics. It has higher saponification, Reichert Meissl and Kirschner values, density, melting point and lower butyrorefractometer index, Polenske, acid and iodine values.
Further, the preponderance of long chain saturated fatty acids like palmitic and stearic acids make the buffalo milk fat harder than cow milk fat, which is of value in developing the granular texture in ghee obtained from this milk (Ramamurthy, 1976). The particle size of buffalo micellar casein has been established to be significantly larger (135 nm) as compared to cow casein micelles (90 nm). The rennet stability of buffalo milk (25.6 min) is lower than for cow milk (28.2 min). Castagnetti et al. (1996) reported that buffalo milk upon renneting, displayed good coagulating properties in terms of clotting and curd firming rates, and curd firmness. Unlike cow milk, buffalo milk imparts a distinct whitening effect to tea and coffee because of its high content of casein and whey proteins.

**Table 7: Physical properties of buffalo and cow milk***

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Buffalo milk</th>
<th>Cow milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density at 20°C</td>
<td>1.0310</td>
<td>1.0287</td>
</tr>
<tr>
<td>pH at 20°C</td>
<td>6.7</td>
<td>6.6</td>
</tr>
<tr>
<td>Buffer value (at pH 5.1)</td>
<td>0.0417</td>
<td>0.0359</td>
</tr>
<tr>
<td>Viscosity (cP at 20°C)</td>
<td>2.04</td>
<td>1.86</td>
</tr>
<tr>
<td>Surface tension (Dynes/cm at 20°C)</td>
<td>50.40</td>
<td>51.9</td>
</tr>
<tr>
<td>Acidity (%), lactic acid</td>
<td>0.13</td>
<td>0.15</td>
</tr>
<tr>
<td>Heat capacity (Cal./g°C at 30°C)</td>
<td>0.852</td>
<td>0.933-0.954</td>
</tr>
<tr>
<td>Thermal conductance (kCal./cm.°C at 37°C)</td>
<td>0.569</td>
<td>0.460</td>
</tr>
<tr>
<td>Electrical conductance (mmhos)</td>
<td>6.62</td>
<td>6.69</td>
</tr>
<tr>
<td>Freezing point (°C)</td>
<td>-0.545 to –0.544</td>
<td>-0.570 to –0.530</td>
</tr>
<tr>
<td>Curd tension (g)</td>
<td>32.85</td>
<td>28.54</td>
</tr>
<tr>
<td>Refractive index</td>
<td>1.3448</td>
<td>1.3338</td>
</tr>
<tr>
<td>Average size of fat globules (μm)</td>
<td>5.01</td>
<td>3.85</td>
</tr>
<tr>
<td>Redox potential (Volt at 20°C)</td>
<td>0.539</td>
<td>0.536</td>
</tr>
</tbody>
</table>

* Laxminarayan and Dastur (1968).

**Nutritional Advantages**

Buffalo milk has higher calorific value of 117 Calories/100 g as compared to cow milk (89 Calories/100 g), which is entirely due to the higher fat, lactose and protein contents in the former. The total cholesterol content was significantly higher in cow ghee (330 mg%) than in buffalo ghee (278 mg%). Free cholesterol
content was significantly higher in cow ghee (283 mg%) than in buffalo ghee (212 mg%), whereas esterified cholesterol was significantly higher in buffalo ghee (Bindal and Jain, 1973). Most significantly, the lower cholesterol value could be exploited to make it more popular in the health conscious market. The ghee prepared from buffalo milk has higher vitamin A and E contents and appreciably lower levels of cholesterol (Sahai, 1996). Among the polyunsaturated fatty acids, the tetraenoic and pentaenoic acids, which are nutritionally important, are higher in buffalo milk fat. Similarly, the higher taurine content in buffalo milk (59 moles/litre) compared to 41.4 moles/litre in cow milk is considered better for infant because of its beneficial role in the absorption of fat. Thus, buffalo milk fat is considered superior for human nutrition.

The higher whey proteins content in buffalo milk further increased food value. In addition, with the development of functional foods employing the beneficial role of milk and milk products in human health has led to the growth of products containing buffalo milk proteins viz. immunoglobulins, lactoferrin, lactoperoxidase, etc. Further, a significantly lower concentration of urea i.e. 17-22 mg% in buffalo milk is considered better for the infants. Besides, buffalo milk is rich in oligosaccharides, which possess immuno-stimulant activity (Saksena et al., 1999).

From minerals profile also, the lower sodium and chloride contents, higher calcium content and higher ratio (1.8) of calcium/phosphorus compared to 1.2 for cow milk is considered good for infant feeding. Boghra (1988) found that buffalo milk shrikhand is rich in minerals including calcium, magnesium, phosphorus, copper, iron and zinc compared to cow milk Shrikhand. Besides, the inherent nutritional qualities of buffalo milk, Sharma and Darshan Lal (1998) reported that from processing point of view, buffalo milk is better as the losses of thiamin, riboflavin and Vitamin B6 were higher in cow milk than in buffalo milk when both kinds of milks are subjected to pasteurization (63°C for 30 min), boiling (conventional and microwave) and sterilization (121°C for 15 min).

Advantages of buffalo milk in the manufacture of dairy products

The chemical superiority of buffalo milk over that of other species makes it preferable for processing as fluid milk and in the manufacture of several Indian and western dairy products. Generally speaking, buffalo milk is more suitable for the manufacture of dairy products as compared to cow milk. Among the different milk products, superiority of buffalo milk is shown as:

Liquid milk: It forms a thick cream layer. The viscous nature of buffalo milk further exerts an additional impact on the consumer’s preference.
**Concentrated milk:** Buffalo milk is as stable to heat as cow milk if not more in its concentrated form. Since buffalo milk is of Type A with maximum stability coinciding with its natural pH, any alteration in its pH leads to destabilization. Tayal and Sindhu (1983) claimed that buffalo concentrated milk is slightly less stable compared to cow concentrated milk due to the more shift in its pH of maximum stability towards acidic side than the decrease in its natural pH during concentration. Bhanumurthi et al. (1971) have, however, standardized technique for the production of buffalo sweetened condensed milk. They reported that high preheating temperature (115-118°C) could be employed as a critical factor in the manufacturing method. Ghatak and Bandyopadhyay (1992) suggested that urea and 2-deoxyribose can be added to buffalo milk during processing to overcome heat stability, browning, flavour and viscosity problems in concentrated sterilized buffalo milk. Further, Prasad and Balachandran (1987) have successfully manufactured sterilized concentrated buffalo milk using suitable levels of mixed stabilizers consisting of disodium phosphate, trisodium citrate and κ-carrageenan. Balasubramanian and Basu (1954) reported that kheer, an indigenous cereal-based concentrated milk product mainly prepared from buffalo milk for immediate consumption.

**Fat-rich milk products:** According to Ismail et al. (1974) buffalo cream churns much faster at higher fat levels and gives higher overrun than cow cream. Due to bigger size of globules and higher proportion of solid fat in buffalo milk, the separation of cream and churning of cream is easier and loss of fat in skim milk and buttermilk is much less. Buffalo milk produces butter with significantly higher yield due to its higher fat content compared to cow milk. Akhundov and Mamedov (1964) reported that buffalo milk cream containing 30-38% fat and pasteurized at 90-95°C was most suitable for butter making, the optimum churning and working temperature being 14-17 and 15-16°C, respectively, for a 99.5% fat recovery. The flavour score for butter prepared from buffalo cream was always higher than that of butter prepared from cow cream. Further, in keeping quality test, butter from buffalo cream showed more stability than those from cow cream, because of the more solid fat and slower rate of fat hydrolysis in former cream. This might explain why during storage, cow milk fat is more vulnerable to hydrolytic rancidity. The texture of buffalo ghee is better than cow ghee due to its bigger grain size, which, in turn, may be due to more proportion (9-12%) of high melting triglycerides compared to only about 5% in cow milk fat.

**Heat-desiccated milk products:** Buffalo milk is preferred for the manufacture of heat-concentrated milk products like khoa, rabri, keeer and basundi. Evidences have revealed that buffalo milk always results in high yields and superior quality of condensed milk products compared to cow milk.
Khoa (a heat-desiccated Indigenous milk product), a product of great commercial importance due to its use as a base for the preparation of variety of indigenous milk sweets such as burfi, peda, milk cake, gulabjamun, etc throughout the country. Since buffalo milk gives greater yield and has a more desirable softer body and smooth texture because of the presence of proportionately higher fat content, the quality of khoa made from buffalo milk is superior to that from cow milk as the product has moist surface, sticky and sandy texture (Reddy, 1985). Ramamurthy (1976) claimed that the higher emulsifying capacity of buffalo milk fat is due to the presence of higher proportions of butyric acid (50%) containing triglycerides compared to only 37% in cow milk fat, a factor responsible for smooth and mellow texture of buffalo milk khoa. Further, the standards of khoa prescribed under the PFA rules in India, is heavily slanted towards the use of buffalo milk. Moulick et al. (1996) reported that, in terms of chemical, microbiological and sensory attributes, the overall quality of kalakand was better from buffalo milk than that from cow milk.

Heat-acid coagulated milk products: The quality of buffalo milk paneer (an acid coagulated milk product) is superior to that of cow milk paneer. The cow milk paneer is too soft, weak and fragile and after cooking its pieces lose their identity (Sachdeva et al., 1985). The low proportion of solid fat, smaller size of casein micelles and fat globules, and lower colloidal calcium could be the reason for inferior quality of paneer from cow milk.

Although cow milk is preferred for making chhana, the suitable methods have been developed for making good quality of chhana from buffalo milk (Iyer and Rajorhia, 1979). Addition of 0.3% sodium citrate to buffalo milk was found to be effective in producing chhana similar to chhana from cow milk in terms of springiness and quality of Rasogolla prepared from the same (Rao, 1986).

Fermented milk products: The superior body and texture of buffalo milk dahi compared to cow milk dahi could be attributed to the higher total solids, especially fat and protein, the casein micelles and fat globules of bigger size and higher calcium content in the colloidal state (Sindhu and Singhal, 1988). The decreasing lactose level and increasing lactic acid, volatile acids and dissolved calcium during fermentation are faster and of higher magnitude in case of buffalo milk, which in turn results in better body and texture to the dahi (Sindhu et al., 2000). The higher flavour score of buffalo dahi could be due to its high citrate content, a major contributor of diacetyl and acetoin formation. Ghosh (1986) reported that misti dahi from buffalo milk is popular in Eastern belt of India.

Buffalo milk is also suited for making yoghurt of improved body and texture, because of its higher total solids content (13-17%) as compared to cow milk. Further, there is no need of its prior concentration or addition of milk powder to obtain optimum body when buffalo milk is used. It is reported that the growth of
yoghurt starter culture is faster in buffalo milk and produced more acetaldehyde, a key flavour component, than in cow milk and thus resulted high organoleptic scores in final product (Singh and Kaul, 1982). Roushdy et al. (1996) have claimed a method of production of acidophilus and bifidus buttermilk from buffalo milk, which can be used as dietary adjuncts with effective therapeutic action.

The *chakka*, a base material of *shrikhand*, is preferentially prepared from buffalo milk because the curd obtained from cow milk is soft, weak and of low curd tension but curd from buffalo milk is hard, smooth and mellow. The yield of *Shrikhand* from buffalo milk is about 15-20% more than that from cow milk. *Shrikhand* and *chakka* made from buffalo milk are extremely nutritious and are popular among Indian masses. Buffalo milk is preferred for making *shrikhand* due to higher yield and better quality of the finished product (Kadan et al., 1984).

**Cheeses:** Since buffalo milk produces Mozzarella cheese of excellent quality, technology for its large-scale production by rennet coagulation as well as direct acidification was standardized. El-Tahra et al. (1999) reported that the most suitable Labneh, an Egyptian Cheese was produced from buffalo milk as compared to that produced from cow or recombinant milk. Akhundov (1959) examined the suitability of buffalo milk for making Edam cheese and determined the optimum manufacturing conditions. Rajesh et al. (1993) reported that addition of 1.5% combined starter CH8 and *Leuconostoc spp.* to buffalo milk resulted excellent Gouda cheese in terms of flavour, body and texture development. Abdel-Rafee and Salem (1997) reported that Ricotta cheese made from buffalo milk with 4% fat had the best quality and sensory characteristics. It has been generally observed that buffalo milk is not quite as satisfactory as cow milk for the preparation of hard varieties of cheese such as Cheddar and Gouda, because of slower rate of acid production, lower retention of moisture in the curd, and higher losses of fat in the whey. The product obtained has a harder body, lower moisture content, higher protein and fat content, slower ripening than cow milk cheese. Some modifications in the procedure have also been suggested for improving the quality of cheese, e.g. dilution of milk, modification in casein : fat ratio, a lower cooking temperature for a short time, etc (Dastur, 1956).

**Frozen milk products:** In comparison to cow milk, ingredients from buffalo milk viz. skim milk powder and whey solids produce better body and texture in ice cream (Patel and Mathur, 1982). Further, the higher protein content in SNF portion of buffalo milk may help to make ice cream more compact and smooth and has tended to prevent a weak body and coarse texture. A survey conducted in USA showed that vanilla was the most popular flavour in ice cream (Steinitz, 1978). By the virtue of greater opacity of casein micelles, coupled with higher levels of colloidal proteins, calcium and phosphorus, buffalo milk is more densely
whiter as compared to cow milk. Hence, use of buffalo milk solids in ice cream may improve sensory appeal especially in vanilla ice cream where no colour is added.

**Dehydrated milk products:** Buffalo milk and cream are intrinsically whiter and more viscous. Hence, buffalo milk is more aptly suitable for the production of tea and coffee whitener powders. The whey proteins of buffalo milk are more resistant to heat denaturation as compared to the whey proteins of cow milk and thus dried buffalo milk may be preferred over dried cow milk for those technological applications where higher levels of undenatured whey proteins would be more desirable. Rizvi (1970) manufactured instant buffalo skim milk powder with added advantage of high reflectance value by single pass method. Development of new dehydrated dairy products viz cream powder, butter powder, ice cream mix powder, malted milk powder, cheese powder, *shrikhand* powder and dried *chhana* from surplus buffalo milk has received some attention of the dairy industry (Balachandran and Rajorhia, 1988). A study showed that Buffalo buttermilk powder exhibited better functional properties viz. solubility, emulsion stability and activity as compared to cow buttermilk powder (Taha and Metwally, 1995).

It is, therefore, evident that buffalo milk is commercially more viable than cow milk for the manufacture of fat-based and SNF-based milk products. Further, higher innate levels of fat and protein render buffalo milk a more economical alternative to cow milk for the manufacture of caseinates, whey protein concentrates and a wide range of fat-rich dairy products. The market for traditional milk products in India exceeds far than that of Western types. Indigenous milk products are gradually becoming popular among the migrating Indian population spreading all over the world. Since a range of indigenous milk products more suited to buffalo milk are made in India, the increasing demand for these products presents a greater opportunity for the increased use of this milk. Hence, lot more research and development efforts are needed to take care of traditional milk products, which enjoy a sizable demand in the market. Similarly, in spite of the initial skepticism and difficulties in adopting western technology for buffalo milk, new technologies are available today for manufacturing milk products from buffalo milk.
Chapter 13

ROLE OF PRIVATE SECTOR AND ITS COLLABORATION WITH PUBLIC SECTOR

The Dairy Industry in the region is characterized by small holder production system and unorganized market structure dominated by the local milkman/dudhiya and halwai leading to a complex supply chain that is compounded by a lack of proper cold chain facilities and logistics. There is low return on investment to the farmers and minimal value percolation to the base of the chain. Public private partnerships (PPP) in this context are the best vehicles to achieve all round sustainable development in the dairy sector. It is hence important that the private sector investments get accelerated in this very important space which is by and large is negligible in SAARC region.

Public private partnerships (PPP) is long term formal agreement between government or public bodies and the private sector agencies specifically aimed at providing finance, design and implementation of projects for certain infrastructure facilities and services which were conventionally provided by the public sector agencies only. This type of collaborative ventures encompasses a formal agreement between the partners pertaining to dedicated allocation and utilization of resources, amount of decision taking power, risks and return. The PPP framework ensures that the private players finances, builds and operates the project with innovative technologies and professional expertise to attain maximum efficiency whereas the quality of service, price certainty and cost-effectiveness is taken care of by the govt. agencies. One more important aspect of the PPP model is the amount of risk sharing in the agreement. The government assumes the responsibility for the social, environmental and political risks related with the project whereas the private partner undertakes the onus for the commercial and financial risks to some extent. In this era of wide-ranging growth, PPPs can serve as a major step towards development of people and economy of India on the whole. The PPP models have been overwhelmingly successful in driving a major wave of urban infrastructure development but now the onus lies on the Government to expand the scope of these partnerships into new horizons of rural development (Chand, 2010) in general and dairy sector in particular.

The need to foster such arrangements in the dairy sector is corroborated by the public sector’s inability to provide certain public goods and services entirely on its own in an effective and equitable manner because of lack of resources and management issues. There is an urgent need not only to improve the supply chain and quality parameters but also to remove the bottlenecks in the sector by fostering private sector participation in the areas of project financing, capacity
building, operations and better integration of stakeholders (Jaisridhar et al., 2012). The establishment of efficient supply chains requires the creation of relationships, networks, skills, and coordination mechanisms to manage the flow of products between intermediaries and to ensure that quality specifications are met. In most cases involving High Value Agriculture, the private sector has facilitated the establishment of networks, often sourcing from large farmers who may or may not contract out to smaller firms (Dolan and Humphrey 2000).

There are certain thrusts areas in regional dairy sector where the Public Private Partnership (PPP) model could be taken up as a synergistic collaboration to achieve the social objective of percolating benefits to the last level of the supply chain and on the other hand provide lucrative proposition to the private agencies as well. Public–private partnerships (PPPs) can play a key role in strengthening links within the supply chain, particularly where market failures impede access by the poor (Rich & Narrod, 2010). In the face of these market failures and externalities, public–private partnerships (PPPs) can play a key role in strengthening and enhancing links within the supply chain, particularly for small producers who may otherwise be limited in their ability to participate in innovative supply chains (Boselie et al., 2003; Hartwich et al., 2003).

The potential thrust areas where the private sector can intervene alongwith certain key recommendations given by Jaisridhar et al. (2012) with regard to policy measures and incentives in terms of facilitating subsidy, grant-in-aid or in other terms to facilitate a healthy environment for the growth of a well-built symbiotic relationship which can provide a right platform for initiating white revolution are discussed below.

**Milk production and increasing productivity:** In in the region, the average milk productivity is very low in comparison to the productivity of exotic breeds in developed countries (Mahadevan, 2008). The PPP can play major role in filling this huge gap in the production standards and boosting the overall yield and productivity parameters. Regional dairy sector has a tremendous potential to set new benchmarks in the world dairy market having the largest milch animal base given persistent efforts to increase the productivity. Contract farming in the sector has been widely adopted as a viable business model by the cooperative unions and the private sector players for providing assured and reliable inputs service to the farmers and desired quality of milk to the contracting dairies. The unions and private sector players provide the technical services for improving the productivity of animals, distribution of fodder seeds and cattle feed and veterinary services.

**Procurement and Processing:** The procurement and processing side being the most vital part of the supply chain in the dairy sector, the participation of private sector for identification of potential milk pockets, development of strategic
locations for milk collection, and setting up collection network and processing facility on design-build-own-operate basis is essential in improving the procurement and processing function in dairy. In order to promote PPP the procurement and processing function the government need to assign a special priority sector status to dairy industry, allocate special budgetary provision, provide institutional finance at reduced rates of interest to kick start the projects, and develop guidelines on the competitive procurement price of milk at the farm gate.

**Infrastructure and Logistics Development:** The gap in infrastructure and support logistics is probably the most important cause for the minuscule share of processed and hygienic milk. There is lot of scope in developing infrastructure such as bulk milk coolers units (BMC) and chilling facilities, animal feed processing and milk processing plants, milk testing facilities, cold chain having a fleet of refrigerated vehicles and insulated stainless steel tankers etc. on build, own and operate basis in PPP mode. Also there are many defunct and sick cooperative milk plants which can be revived lease develop and operate basis in PPP mode (Figure 27).

In order to foster infrastructure and logistics development in the dairy sector the government could facilitate a conducive environment by providing land at a subsidized rate for building bulk milk cooling units and dairy plants, special category status to such land, duty exemption on import of capital goods, subsidized electricity supply to the bulk cooling units and milk chilling plants, besides promulgating specific policy measures for including certain lucrative funding patterns and incentives, and facilitating commercial lending by banks and financial institutions for dairy projects.

![Diagram](image.png)

**Figure 27: The potential thrust areas in the Indian dairy industry for the PPP to intervene**
(Source: National council for PPP)

140
**Operations Management:** Perfect management of various operations like manufacturing and production systems, plant management, equipment maintenance management, production control, industrial labor relations and skilled trade supervision, strategic manufacturing policy, systems analysis, productivity analysis and cost control, and materials planning is key to the success in sustaining a dairy processing plant business. PPP in this context can help through contracting-in models which would entail hiring of one or more number of agencies to cater to an array of services required in dairy processing plant.

**Capacity Building through Training:** Private players can play a key role in capacity building and training through PPP modes by working in synchronization with the public sector for the effective utilization of the already existing milk zones and cooperative structures. The govt. can further facilitate this by allowing corporate entities to set special vocational training institutes for the dairy processing technology and providing subsidies for the private institutes for infrastructure building, running the courses, and to some extent bear half the fees burden of the students so that dairy education becomes affordable and lucrative.

**Advisory and Extension Services:** The PPP in advisory and extension services is occurring rapidly in certain countries through private business ventures and non-governmental agencies as alternative service providers (Kahan, 2008). This shift in approach is encapsulated by the development of Business Development Services (BDS). This readjustment of extension services is a classic case of public-private sector co-operation.

**Research and Knowledge Transfer:** The intervention of private players in research in dairy sciences renders tremendous potential. While the public sector will have to continue playing important role in focusing on basic research and in the development of prototype technologies, the public-private partnership in applied research can have the large potential payoffs in terms of added value. The public sector will have to play a major role in initiating and encouraging public-private cooperation as collaborative endeavors in performing dairy research, funding and managing that research as well as establishing intellectual property rights over the results of research. While the potential for collaboration exists, there have been obstacles in finding effective ways for its operationalisation. The common questions posed are: who should take the lead and how should collaborative funding arrangements be made? Competitive funds have been used in some situations to help mobilize the necessary resources. The challenge is to identify the minimum set of conditions that must be met in order to establish effective and equitable partnerships (Kahan, 2008).
Chapter 14

DAIRY DEVELOPMENT IN SAARC MEMBER COUNTRIES: THE WAY FORWARD

All the SAARC member countries are dominated by smallholder dairy production system. Smallholder systems can often result in low bargaining power and limited ability to capture economies of scale in marketing. Smallholders may also have poor access to livestock services such as veterinary services, artificial insemination and credit for feeds and replacement cattle compared with larger-scale producers. Therefore, following policy interventions are necessary to provide additional support to their viability.

1. **Promoting strong producer groups**: There is a need to form strong producer groups so as to increase their current returns from milk production through effective organisation and small-scale processing (Bennett et al., 2001). Milk producers need to be identified and organized into groups. Producers should be trained in group formation and business management activities such as record keeping, simple business transactions, pesticide applications, storage practices, pooling production and community resources, negotiating contracts, production planning, and supplying quick alert information on animal diseases (Narayanan and Gulati, 2002). Milk Producers’ Organisations (MPOs) should establish producer group with centralised milk processing units.

2. **Ensuring support services**: Milk Producers’ Organisations (MPOs) should provide “Support-Services” to increase clean milk production. An effective and well trained animal health service should be available at any time to look after the health of animals, arrangements should be made for regular vaccination and checking against contagious diseases by the qualified veterinarians. Veterinary first aid should be readily available around the clock at village level. To avoid spoilage, milk collection centres should be set up at locations where producers can easily access. Milk producers’ organisations should have their own low cost and small-scale milk processing units for manufacturing of dairy products and marketing to maximise returns to the producer (Bennett et al., 2001).

3. **Greater vertical integration**: This is important for maintaining efficiency in the procurement supply chain and particularly in meeting food safety and quality standards. These can be achieved through institutional innovations such as cooperatives, contract farming and clustering. Vertical integration
also helps in reducing wastage, ensuring quality standards and attaining scale economies in dairy processing. Development of cooperatives has to be promoted, and reckless government intervention in management of cooperatives should be checked. There is a need to establish appropriate legislative frameworks, contract enforceability, etc. so that small holders are benefited from vertical coordination (Narayanan and Gulati, 2002).

4. **Promotion of organized dairying:** Organized small-scale milk collection and processing should be promoted as an alternative model of milk processing by encouraging small dairies at taluka and district levels. Small dairies of 5000-10000 litres of milk capacity which can handle fresh milk distribution and processing for traditional and western dairy products will reduce the cost of handling, maintain hygiene and add value to the product. Decentralized processing can create additional demand for the milk and generate employment at the grass root level. A small dairy of this size should be able to generate year round employment for about 40 persons. With reduction in the cost of milk handling, the retail price of milk can be reduced significantly and this can help us to face the challenge of imported milk products. Such a model would not only serve as a sustainable, income-generating and household food security activity, but also as a means to improving the safety, quantity and quality of milk and dairy products available for consumers. FAO in collaboration with other international and regional partners should be approached to provide technical guidelines and advice for sustainable development of small-scale milk collection and processing.

5. **Financing the dairy sector:** Credit is the single most important constraint for small farmers. Each component of milk value chain viz. production, procurement, processing and distribution requires adequate financial support. It is, therefore, necessary that the banks and other financial institutions need to play the proactive role in providing easy and user friendly credit to the end users through development of area specific schemes and redesigning of their financial products. Chand et al., (2010) proposed introduction of Kisan White Card (similar to Kisan Credit Card) scheme to provide short term credit/working capital to the dairy producers. Under this scheme, the dairy farmers may be sanctioned limit based on their annual income from sale of milk proceeds to augment the dairy development activities like purchase of milch animals, construction of cattle shed, purchase of milking machines, feed and fodder cultivation etc. This also would require re-designing of livestock insurance products so as to tackle the critical issues of ascertainment of livestock during claim settlement process and the identification of the reasons for the death of the animal. Another alternative
could be financing to dairy farmers for the purchase of milch animals through district level milk cooperative unions/private dairy plants to provide hassle free production loans with minimum probabilities of turning into bad asset. In addition to this, Government should take some proactive steps to encourage the semi-formal Micro-Financial Institutions (MFIs) to play active role in financing dairy farming.

6. **Diversifying processed dairy products**: Diversification through modernization of product manufacturing, new product development, food safety and quality management is necessary for maximizing returns from milk production. Following interventions are required in this direction:

A. **Modernization of traditional dairy products Sector**: The traditional dairy products being the largest selling and most profitable segment of dairy industry in all the SAARC nations, it is necessary to recognize the importance of indigenous products to sustain its overall growth. Also, enough attention and investments are necessary to raise the status of this product category from a dominantly unorganized to the organized and allow it to emerge as a mature segment of the industry. With opening of the trade restrictions, post-WTO, new opportunities hitherto non-existent have emerged for the manufacturers of the traditional dairy products on large scale by the organized dairy industry. A niche global market has strongly emerged for ethnic dairy products. Indications are that the market is fast growing with considerable future potential. Large populations of SAARC origin settled in Oceana, Middle East, Western Europe, and North America represent a lucrative export market. There is an opportunity to take advantage of this niche market by developing dairy products of ethnic origin meeting the quality and standards required for the global market. The full potential of the traditional dairy sector can be tapped using strategies for modernization delineated below:

- **Production of traditional milk products by organized sector**: Large-scale manufacture of these products in a hygienically safe manner with assured quality control and proper packaging will certainly do wonders for this sector. The organized production of indigenous dairy products, however, is miniscule as compared to total volume traded in the market. By 2020, it is necessary to shift at least 25% of production of traditional dairy products to the organized sector. In spite of several innovative efforts made in the mechanization of manufacture of traditional dairy products, adoption of these innovations by the industry is very limited. It is necessary to develop batch type equipment so that mechanization of production in the small size units in the unorganized sector is effected thereby improving the hygienic quality of the products marketed by this sector. The organized production does not
necessarily mean large-scale production. Large number of small and tiny manufacturing units engaged in the unorganized sector cannot be ignored. A number of them have people with great innovative capabilities and basic skills. These talents need to be properly organized for hygienic production and marketing. There is also a need to facilitate formation of consortia of dairy industry to fund research to (i) develop mechanized and energy efficient systems for manufacture and packaging of traditional dairy products and (ii) develop value added traditional dairy products for the future.

- **Packaging of traditional dairy products:** Poor packaging of traditional dairy products is another big area, which should be strengthened. Most of these products particularly sweets are sold in open condition which is great source of contamination. Even products prepared by organized/large dairies, for example khoa and paneer are not properly packaged. No packaging system/machine is available for traditional milk sweets and the units available for non-dairy sweets are unsuitable for milk sweets. The methods of manufacture of many sweets also do not commensurate with the continuous packaging system. The appropriate and environmental friendly packaging materials are to be identified. Complete packaging systems that are in harmony with the production line will have to be adopted.

- **Training of small-scale operators:** Most of the trade of traditional milk products is with the halwais and the small-scale operators. Most of them have art and skill of manufacturing varieties of traditional dairy products. However, no attention is paid by them on quality of milk, hygienic handling, proper packaging and storage due to ignorance. The training of operators in this sector in hygienic handling and quality control aspects will go a long way in improving the quality of these products. The regional Agricultural Universities and *Krishi Vigyan Kendras* will have to play active role in training of small entrepreneurs.

- **Understanding basic characteristics of traditional dairy products:** In order to modernize the traditional milk products sector, it is necessary to understand the basic characteristics of these products. The knowledge of these characteristics would contribute a great deal in design of equipments and standardizing scaled-up methods for manufacture of these products.

- A variety of traditional dairy products are produced in countries like India, most of which are region specific. Most of these products have been characterized for their chemical composition, sensory attributes and rheological and microbiological characteristics. Wide variation in composition of these products is observed due to variation to the method of manufacture, concentration ratio used, sugar level, type of milk (i.e. cow, buffalo or mixed). There is a need to determine the consumers’ preference
about the most desirable attribute of these products in different regions of the country so that the organized dairies may adopt the same.

- Similarly, characterization of various food products on the basis of their rheology and microstructure forms the backbone of the scientific approach to product/process development and of quality assurance in modern industrial practices. The current trends round the globe favour such studies to facilitate product description/specification for promoting process control and for international trade. In the past few years, some work has been directed to study the rheology and microstructure of selected traditional milk products such as paneer, khoa, rasogolla and sandesh. It is also necessary to understand the kinetics of texture formation during manufacture of these products and the molecular level changes in the constituents of milk during processing. Any equipment designed without taking into consideration these basic aspects is less likely to be accepted by the industry as the product obtained using such equipment would lack the desirable texture.

- Establishing national standards for traditional milk products: Lack of quality/legal standards and quality assurance systems is one of the bottlenecks in improving the quality of these products. While legal standards for some of the traditional milk products have been laid down, there is an urgent need to formulate the national standards for all the traditional milk products marketed in SAARC countries. There is also need to evolve the quality assurance system to meet the international standards of food hygiene and food safety.

- Innovation in value added traditional milk products: The markets of conventional indigenous products are increasingly getting overcrowded and our future success will depend on our ability to provide innovative products, which consumers want and need. Whatever the innovation - products, processing method or packaging - it should meet the real consumer need. We know today’s families want “grab-and-go” convenience. They are also concerned about nutrition and health. Different ages and demographics want different things. Therefore, investment at this level is essential if we are to respond rapidly to customers who are increasingly demanding new and different taste experiences from products that are also competitively priced. New variants of sweets can be developed. Indigenous dairy products containing health-promoting ingredients may be developed and promoted. Host of ingredients such as dietary fibre, cholesterol reducing phytosterols & phytostanols, minerals and vitamins, berries and cherries with its anthocyanins that prevent cancer etc. are available for value addition of traditional dairy products. Development of dietetic sweets is another area needing attention.
Innovation in marketing: Innovation in marketing is equally important. It is possible to popularize traditional milk delicacies through the fast food chains or franchising of some popular brands of Indian dairy delicacies may be promoted. Collecting market intelligence to inspire confidence among prospective entrepreneurs to take commercial production of traditional dairy products is also essential.

B. Value addition with buffalo milk: Buffalo milk constitutes significant proportion of the total milk production in India, Nepal and Pakistan. It has several special features, which need to be focused in our R&D effort to create values in dairy products. Technological modifications for manufacturing several dairy products from buffalo milk have been already standardized. Buffalo milk have special advantage for production of several products such as mozzarella cheese, paneer, khoa and khoa based sweets, dairy whitener and several health foods like dahi, yoghurt, acidophilus milk, etc. Buffalo milk is richer in fat, SNF, Ca and P contents and also contains fat globule of larger size, besides showing other interesting physical and chemical differences. BM fat is superior fat with regard to less cholesterol and more tocopherol, which is a natural antioxidant. Due to higher proportion of High melting triglycerides and bigger size of fat globules in buffalo milk, the separation of cream is easier and results in better texture of ghee. Further, due to higher casein and calcium content, more so in the colloidal state, buffalo milk yoghurt and paneer are superior in body and texture. BM is usually preferred over cow milk for khoa making, since the former gives greater yield and has a more desirable flavour, body and texture. BM is also considered more beneficial for infant feeding due to the better absorption of fat, higher content of lactoferrin, less content of urea and higher ratio of Ca and P. The competitive advantages of buffalo milk therefore, needs to be fully exploited for value addition and development of new products with special attributes.

C. Convenience dairy products: Demand for ready-to-consume milk based products such as puddings, desserts, stirred and set yoghurt, cheese and butter spreads and slices, milk powder biscuits, acidophilus milk, sour cream dip and sauces, etc is growing. Similarly, ready mixes of traditional milk products such as gulabjamun mix, kheer mix, kulfi mix, rasogolla mix, etc. show good promise. In their production, there is ample scope for value addition, which helps strengthen the bottom line of the organized sector dairies. The organized sector is now taking firm strides in new directions to tap the multiplayer market for traditional and trendy milk products. Its future growth would largely come from the value-added milk product segment.
D. **Dairy ingredients in health foods:** Milk components not only provide nutritional security but also are capable of providing potential health benefits in their various forms. Many dairy ingredients are finding large-scale application in neutraceutical products, which are possibly the hottest trend in the food industry. Neutraceuticals are the foods that provide benefit beyond basic nutrition and many prevent diseases and/or promote health.

Casein is the major milk protein, which naturally form the micellar structure by incorporating calcium and phosphate ions thus providing a source of phosphopeptides. The enzymatic hydrolysis of casein can produce casein phosphopeptides, which enhance absorption of calcium by forming soluble complexes. Other minerals such as iron, manganese, copper and selenium are also sequestered by casein phosphopeptides. Potential applications include calcium-enriched tablets, instant drink mixes, confections and a number of other fortified products. Milk protein hydrolysates, depending on the degree of hydrolysis increases digestibility, nitrogen absorption and decreases protein allergenicity. It is, therefore, suited for sport nutrition products, protein tablets and instant drinks.

Whey proteins are rich in lysine, leucine and sulphur containing amino acids, which maintain antioxidant levels in the body and stabilize DNA during cell division. Whey proteins are known to have shown beneficial effects on chemically induced cancers, stimulation of immune system, and release of cholesystokinin-an appetite suppressing hormone, besides lowering of LDL cholesterol levels. High level of branched chain amino acids (leucine, isoleucine and valine) in whey proteins directly supply energy to the skeletal muscles unlike other amino acids, which are first metabolized through liver. They are therefore valuable for athletic drinks.

Among different fractions of whey proteins, β-lactoglobulin is considered a retinol-binding protein and thus supplies vitamin A to the new born. α-lactalbumin binds metal ions like calcium and is known to possess anti-tumor effects.

Bioactive proteins viz. lactoferrin, lysozyme, lactoperoxidase, folate binding protein and induced bioactive components are generating lot of interest among food researchers because of their tremendous potential for value addition. Lactoferricin, which is the proteolytic breakdown product of lactoferrin, possesses broad-spectrum activity against pathogenic bacteria and yeasts. Lactoferrin may therefore find applications in infant formula, nutritional bars, sports and performance products. Lysozyme and lactoperoxidase are effective antibacterial proteins. The lactoperoxidase system is already used for acne preparations, shampoos, toothpaste, soft-serve ice cream and pastry cream. Many induced bioactive peptides with
either casein or whey protein precursors have been identified in milk. Casomorphines are peptides derived from casein. Some are opioid agonists while others are opioid antagonists. Many of these phosphopeptides may perform the function of carrying minerals. Glycomacropeptides stimulate the release of choleystokinin, which plays a role in regulation of digestion and functions as an appetite-suppressant. Immunoglobulins, which are present in high concentration in colostrums, have found applications in treatment of AIDS-related symptoms such as cryptosporidia diarrhoea.

Milk fat also contains potential anticarcinogenic components, including conjugated linoleic acid (CLA), sphingomyelin, butyric acid and ether lipids. CLA, in many nutritional studies, have been found to inhibit the proliferation of human malignant melanomas and colorectal, breast and lung cancer cell lines. Butyric acid is capable of regulating cell death by inhibiting uncontrolled proliferation and supporting normal apoptosis (normal cell death), in a number of cancer cell types. The following list summarizes physiological functions of many milk components and/or milk products.

Use of dairy ingredients in health foods has opened unlimited scope for value addition. The dairy industry, in many parts of the world has developed cost effective processes to fractionate bioactive components for commercial applications. Product designers in SAARC member countries also need to raise to the occasion and offer product formulations with demonstrable health benefits so that the industry has more options for value creation and diversification. 7. **Addressing potential non-tariff barriers:** In order to address the potential non-tariff barriers in external markets it is necessary to comply with the WTO SPS requirements by developing food safety policy, updating the existing legal and regulatory framework to reflect new and emerging food safety concerns in internal and external markets, and translating international standards (GAP and HACCP) into producer/processor codes of practice.

8. **Ensuring Food Safety through Novel Techniques:** Microbiological safety of milk and milk products is now the foremost issue confronting Dairy Industry. To make any worthwhile impact both in the local and highly competitive International market, the Industry has to make sure that the dairy products manufactured within the country are absolutely safe and free of high risk pathogens particularly *Salmonella* and *L. monocytogenes*. Hence, there is a need to develop cost effective, reliable and simple ready to use kits for rapid detection of these pathogens at field level. Development of such ready to use kits and their subsequent introduction in Dairy Industry and other food labs deserve immediate attention and top priority.
so that dairy products could be quickly monitored on routine basis for these pathogens before release into the market for local consumption as well as for export. There is also a need to conduct research on the development of rapid methods for detection/determination of newer adulterants in milk and milk products. The kit developed should be further improved to include more number of tests like detection/determination of organochloro/organophosphates and organocarbamate pesticide residues in milk and milk products for routine monitoring of their level and detection/determination of level of various antibiotics. Rapid methods for the detection of both spoilage and pathogenic microflora to assess the quality and safety of dairy products are also necessary.

The advancement in the field of instrumentation, biosensors and chemical-biology could be exploited to develop protocols which will authenticate the milk and a finger-print profile of good quality milk could be developed. A hand-held instrument could automatically scan incoming ingredients or milk for abnormality and trigger immediate removal from the supply line. Biosensor-based rapid diagnostic techniques in the shape of convenient kits in near future and devices which can be integrated into the process lines and product handling environments in coming decades would help meet the growing demands of the industry trying to attain high quality status for its products. Biosensor based analytic techniques need to be developed for the detection of antibiotic residues, pesticide residues, pathogens and enterotoxins in wide variety of food products.

9. In addition to the above-mentioned points, there are areas where major thrust is required such as:

- Brand image needs to be projected in leading international dairy trade fairs, particularly of those countries to which exports are being targeted,
- Encourage technical collaboration and marketing tie-ups with leading international dairy companies, and
- R & D for diversification of dairy products with emphasis on nutraceutical, functional and therapeutic value through biotechnological applications represents newer opportunities for creating niche markets.
REFERENCES


FAO (2010). Dairy sector study of Nepal


Katawazy, A. S. (2013). Investment opportunities in Afghan dairy & livestock, research, planning and policy directorate, Afghanistan investment support agency


Md. Abdur Razzaque Mia (2013). National livestock extension policy – Bangladesh
Pal, S. K. and Siddiky, M. N. A. (Eds.) (2011). Dairy production, quality control and marketing system in SAARC member countries. SAARC Agriculture Centre (SAC), BARC Complex, Dhaka, Bangladesh


SOURCE OF DATA

Statistical data book for Agricultural research and development in SAARC Countries 2008-2009 (2012). Published by SAARC Agriculture Centre, BARC Complex, Dhaka, Bangladesh

Afghanistan National Livestock Census (2008). Food and Agriculture Organization of the United Nations, Rome, Italy


Annual Report (2012). SAARC Agriculture Centre (SAC), BARC Complex, Dhaka, Bangladesh

Basic Animal Husbandry Statistics (2012). Published by Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India


Dairy Sector Study of Nepal (2010). Food and Agriculture Organization of the United Nations UN Complex, Pulchowk, Nepal


Hasnain, H. and Usmani, R. H. 2006-b. Livestock of Pakistan (Chapter on “Services & Infrastructure”). Published by Livestock Foundation. Islamabad. pp.151-156


