Dairy Asia: Towards Sustainability

Genetic Improvement of Dairy Animals in Asia

Strategies for Developing Effective and Sustained Breeding Programmes

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Dairy Asia is a multi-stakeholder partnership committed to visioning and building a sustainable dairy sector in Asia and the Pacific region. Please visit www.dairyasia.org for further information about the platform.

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Contents

Tables

Figures

EXECUTIVE SUMMARY

1. Two-thirds of the world's 800 million under-nourished people live in the Asia-Pacific region. Increasing the productivity of milking animals by 20% could provide sufficient milk to provide a glass of Asian milk for every Asian child each day with attendant benefits to health and education.
2. Demand for milk in Asia is predicted to rise to 320 MMT by 2021. It is clearly desirable that Asia provides fresh milk and milk products for consumption within the region.
3. The vast proportion of Asian milk (80%) is produced on smallholdings and processed/marketed by tens of millions of traders and dairy entrepreneurs.
4. In 2015, FAO published "DAIRY ASIA: TOWARDS SUSTAINABILITY" providing elements of a Regional Strategy for Sustainable Development in Asia.
5. Subsequent meetings identified genetic improvement as a key factor in future dairy production and sustainability, although it must be recognized that management and nutrition will have major and rapid effects which cannot be equaled in the short term by genetic change.
6. Developing strategies is normally complicated, but is made more so by the effects of climate change. The IPCC points out the likely reduction in yields of some important crops, the competition for feeds between humans and farm animals, and the potential advantages of using locally adapted breeds.

Production and Productivity

7. Asia has about 492 million cattle (35% of global population) and 187 million buffaloes (97% of global) with South Asia having the largest populations. In 2013, Asia produced 292.4 million tonnes of milk against the global production of 768.6 million tonnes.
8. There is a vast variation in milk yields among the Asian countries and a large number of breeds involved including many local breeds although in many situations exotics are used for crossing with local breeds.

Dairy Production systems

9. There are many different dairy production systems in Asia. Mixed farming smallholder dairy production systems are predominant. Grassland smallholder dairy production systems are found in temperate pastoral region of northern China. Landless large herd dairy production systems have developed around large cities in India, Pakistan and China such as Mumbai, Karachi, Beijing, Tianjin and Shanghai, whereas landless small herd dairy production systems are found in many parts of rural Asia. Mixed farming smallholder humid/semi-humid systems are predominant in Southeast Asia.

Institutional structure

10. To obtain information on the institutional structures, a survey was undertaken of 15 countries although replies were received from only six– namely, Afghanistan, Bhutan, China, India, Indonesia and Thailand.
11. In general, populations of local cattle breeds have been declining, whereas that of crossbreds (with exotics) has been increasing. While local buffalo populations have been decreasing except in India and Pakistan, crossbred buffalo populations have been increasing.
12. The majority of semen stations are owned by government. In India cooperatives also play an equal role.
13. Likewise, the majority of artificial insemination centres are in government sector. However, AI centres in cooperatives, private and NGO have been steadily increasing.
14. Three of the six countries have developed progeny testing schemes over the last 30 years or so, although, for various reasons, these are not necessarily achieving significant genetic change. All six countries use computerised systems for their genetic improvement programmes.

12. All six identified constraints, priorities and key interventions required.

Strategies for Genetic Change

13. Genetic change is relatively slow but permanent and additive over the generations. The fact that the environment in which future generations will perform will have implications for the breeding goals and that the

values for each of the goals really need to be those of the future (**not present values**) serves to add to the difficulties in decision making.

14. The choice of breed/crosses to be used is crucial as it has massive implications for the strategy to be adopted. Unfortunately, many countries adopted crossing with exotic breeds without reference to the large number of reports of crossing schemes for dairy production and the implications.

15. Any strategy will involve defining breeding goals, developing a structure to identify the best animals and the methods for disseminating the superior genotypes to the industry.

16. Defining breeding goals requires comprehensive consultations with all parties about the **future** needs and the relative future value of each in the context of the producer and the processor/consumer.

17. Developing a breeding structure depends on the extent of AI infrastructure. If a sufficient number of animals are artificially inseminated, progeny testing is a practical and the best option for achieving genetic progress in any population. If AI coverage is inadequate, a breeding structure based on pedigree selection could be considered. Putting in place recording systems and quality control procedures are essential for running any progeny testing or pedigree selection programme.

18. Progeny Testing is the most common system used in dairy cattle breeding. Bulls are compared by the performance of their progenies alongside the progenies of other bulls. In Asia, the plethora of smallholdings presents some problems in achieving the desired contemporary comparisons, but methods have been adopted to mitigate such problems.

19. Such circumstances can delay results to an extent that the generation interval is extended to an unacceptable time. In such cases, Sire to sire and Dam to Sire pathways can be focused to achieve desired genetic progress.

21. Pedigree selection can be used, where accurate records of parentage are available – such recording is really essential for future programmes.

22. The breeding structure can be based on a Nucleus herd providing genetic change to others either directly or by the use of a Multiplier level or, more generally, by using the whole recorded population to identify the future breeding stock.

23. It is essential that, whatever system is adopted, there is a comprehensive information system making data available to all requiring it. This is likely to be by the use of different modules for the various interested groups. It should be recognised here that no information system is effective unless animals are identified uniquely on individual basis by an appropriate identification system.

24. To maintain the quality of implementation of breeding programmes, it is important to set minimum standards, put in place an evaluation mechanism and certify bulls, semen stations and AI service providers.

25 Dissemination is the crucial element in the cost effectiveness of any breeding scheme. Where possible, artificial insemination provides the greatest dissemination of improved genotypes and is the preferred method, but there are situations where it cannot be successfully adopted. In such situations, sons of the best males and females can be used. This affects the 'lag time' between the improved genotypes and the commercial level.

24. The improvement of local breeds is likely to be of greater significance given the effects of climate change. Whilst numbers may be low, it is important that schemes are developed to ensure that genotypes are available for the future – whether to be used as purebreds or to provide the necessary genes for other less adapted breeds.

25. Cross breeding has been a major method of dairy improvement in Asia. While there are numerous reports providing clear evidence as to the most valuable levels of crossing, in general Asian countries have ignored such evidences. Some have adopted individual strategies that commit the country to having its own independent improvement programme which may or may not be effective in terms of genetic change and/or cost effectiveness.

26. In some areas, it is quite possible to use purebred exotic breeds. While it is obviously easier to rely on improvements done elsewhere, it would be

advisable to compare local and imported bulls given that local conditions are almost certainly not precisely the same as those under which the imported exotic genotype was selected.

Research and Development

27. Initially efforts will be required to research the optimal manner in which a local breed can be improved - the strategies may well differ for different breeds.

28. Genome sequencing has developed rapidly and was initially used to identify SNP Markers for different traits. These can be used to supplement other data to improve accuracy for some desirable traits.

28. The use of genomics in dairy breeding has increased dramatically over recent years in many countries. This has not been the case in Asia. Undoubtedly there will be clear benefits from increasing the potential genetic change by the use of genomics. However, it is essential that countries realize that genomic selection requires developing cost effective SNP level genotyping chips for the specific breed being considered (to date SNP level genotyping chips have been developed only for exotic breeds; developing SNP level chips for local breeds may even require whole genome sequencing of a few animals of local breeds) and, more importantly, accurate and detailed phenotypic records of the breed.

29. Investment in future research into SNP level genotyping should carry with it the requirement for accompanying detailed phenotypic records. Understanding the population behavior of SNPs and their transmittance pattern would also be equally important.

30. Monitoring of all aspects of genetic change programmes is essential, but rarely undertaken in Asia. This is an area for immediate investigation.

31. The use of Embryo Transfer (ET) and In Vitro Fertilization (IVF) has slowly evolved, but has been limited to specific aspects mainly due to cost effective considerations. Genomics increases the potential value of these techniques.

32. Bioinformatics is becoming increasingly important in the use of data for genetic change and Asia needs to ensure that it has the relevant expertise fully trained and available.

International Cooperation

33. Standard Operating Procedures would benefit all countries by ensuring that each can comprehend the others and be able to benefit from the experience of those with many years involvement in genetic change programmes. The most obvious area is that of animal recording and the International Committee for Animal Recording (ICAR) is the means by which countries and institutions can use a common methodology (See icar@icar.org).

34. Capacity building is crucial to the development of the dairy industry in Asia. ICAR and INTERBULL are experienced global institutions that could assist in this development within the constraints imposed by the Asian industry structure.

35. Training programmes, seminars, conferences and study tours are all methods by which Asia could benefit from international experiences.

36. Such capacity building requires funding and DAIRY ASIA could be one means by which funding agencies could be approached for assistance. It remains to be seen whether DAIRY ASIA can receive funds from its members for such activities.

37. Exchanges of genetic material either within DAIRY ASIA members or with countries outside will require careful consideration under the Access and Benefit Sharing (ABS) arrangements of CBD. Countries should be aware that the USA has never ratified the CBD and is not bound by it.

38. Joint Ventures should be considered in the same manner as in 37.

Role of DAIRY ASIA

39. DAIRY ASIA is essentially an umbrella for the development of the dairy industry in Asia and can be considered as the Regional Focal Point for the National Focal Point members.

40. DAIRY ASIA can work as a handholding agency to facilitate exchange of both performance and genome data and genetic material across the region and to create a uniform data collection platform.

41. DAIRY ASIA can be the link for the provision of information between and to all members, providing a forum for discussion and a link with global institutions.

42. DAIRY ASIA is not a funding agency although it can assist in project development and proposals to funding agencies.

43. DAIRY ASIA can only be as good as its members' cooperation and commitment.

1.0. INTRODUCTION

The "Strategy and Investment Plan for Smallholder Dairy Development in Asia" (RAP 2008/10) points out that two-thirds of the world's 800 million under-nourished people live in the Asia-Pacific region. It points out that increasing productivity of milking animals by 20% could provide sufficient milk to provide a glass of Asian milk for every Asian child each day with attendant benefits to health and education.

Demand for milk in Asia is predicted to rise to 320 MMT by 2021. It is clearly desirable that Asia provides fresh milk and milk products for consumption within the region. However, milk production must be economically competitive with other potential sources based on a fully internalized cost basis.

The vast proportion of Asian milk (80%) is produced on smallholdings and processed/marketed by tens of millions of traders and dairy entrepreneurs.

It was for these reasons that The Chiang Mai Declaration was made, clearly supporting a smallholder dairy development strategy. This makes it clear that the dairy industry is crucial to the further development of rural Asia.

In 2015, FAO published "DAIRY ASIA: TOWARDS SUSTAINABILITY" providing elements of a Regional Strategy for Sustainable Dairy development in Asia. Comments on the genetic aspects made the point that genetic improvement policies and schemes should be guided not only by milk yield but also all other traits which impact on the overall sustainability of dairy farming.

Subsequent meetings identified genetic improvement as a key factor in future dairy production and sustainability and recommended a Working group to consider such matters even though it must be recognised that management and nutrition will have major and rapid effects that cannot be equaled by genetic change in the short-term. **The only justification for attempting genetic change is that once achieved it is permanent and it is additive over the generations.**

The countries of Asia have, in general, attempted initially to use the genetic abilities of breeds developed and improved in environments not similar to most experienced in Asia and have, unsurprisingly, found that there are serious constraints to such policies. Indeed Asia has a hotchpotch of schemes for the improvement of dairy animals many of which have resulted from having no initial plan and policy for such genetic improvement. It is with this in mind that DAIRY ASIA decided to try to develop a strategy for genetic improvement of dairy animals in Asia. This in no way implies that all schemes will be similar in their modus operandi, but the aim is to attempt to assist countries in developing sustainable and cost effective systems best suited to the conditions under which the smallholders operate.

Developing strategies is normally quite complicated, but is now made even more so by attempting to take into account the effects of climate change. Some changes will be localized, whilst others will have much wider implications. The IPCC points out that crop yields of maize, soya and wheat are likely to reduce globally thereby raising more acutely the competition for such feeds between animals and humans. In addition, grasses will become more fibrous even though yields are likely to rise and IPCC suggests that the use of indigenous breeds may need to be considered more carefully given that exotic high yielding breeds will be likely to suffer to a greater extent.

This paper begins with describing the existing genetic resources in Asia in terms of number of cattle and buffaloes, milk production and productivity, breed type, etc. in Chapter 2. Chapter 3 delineates the existing production systems and the institutional infrastructure, processes and systems in place in Asian countries for the genetic improvement of cattle and buffaloes. Chapter 4 then develops broad guidelines on making appropriate strategies for the genetic improvement of cattle and buffaloes. Identifying priority areas of research, Chapter 5 describes where research efforts need to be focused to evolve sustainable genetic improvement programmes in Asian countries. Finally, Chapter 6 identifies the potential areas of collaboration among Asian countries and Chapter 7 what Dairy Asia can do. The paper concludes with emphasizing the need to evolve appropriate, sustainable and cost effective systems of genetic improvement that suit best to the conditions under which the dairy farmers operate in Asia.

2.0 PRODUCTION AND PRODUCTIVITY OF CATTLE AND BUFFALOES

For developing appropriate genetic improvement strategies for cattle and buffaloes in the Asian countries, it is important to look at the genetic resources in these countries in terms of number, productivity, production, breed type, etc.

2.1 Population of Cattle and buffalo

Asia has about 492 million cattle, which constitutes approximately 35% of the global cattle population (See Table 1). Among Asian countries, the South Asian countries together have the largest population (55.6%), followed by Eastern Asian countries (25.3%), and South Eastern countries (9.5%). The Central and Western Asian countries have 4.4% and 5.3% of the total Asian cattle population respectively.

Table 1: Cattle and buffaloes in Asia, Figures in million

	Cattle				Buffalo			
Region	1993	2003	2013	CAGR	1993	2003	2013	CAGR
South Asia	263.06	250.65	273.34	0.19	109.22	128.35	150.30	1.61
South Eastern Asia	37.55	39.39	46.52	1.08	17.64	14.77	13.29	-1.40
Eastern Asia	91.35	110.93	124.54	1.56	22.22	22.73	23.25	0.23
Central Asia	18.22	14.46	21.55	0.84	0.03	0.02	0.03	-0.05
Western Asia	19.32	18.63	25.97	1.49	0.78	0.58	0.73	-0.36
Total Asia	429.50	434.07	491.91	0.68	149.88	166.46	187.60	1.13
% to total World	33.04	32.23	34.49		96.82	96.99	97.06	
Total World	1300.05	1346.77	1426.06	0.46	154.81	171.63	193.28	1.12

Source:
FAOSTAT

The population of cattle in Asia in the last two decades has grown at a compounded annual growth rate of about 0.68% against 0.46% globally. Among Asian regions the cattle population has grown fastest in the Eastern Asia, followed by Western and South Eastern Asia. In the South Asia, it has remained almost constant in the last two decades.

The majority of world's buffaloes are in Asia – some 97%. The South Asia has about 80% of the total Asian buffaloes, followed by Eastern Asia which has 12% and South Eastern Asia which has 7%. The buffalo population has been growing steadily in South Asia, whereas it has been declining in South Eastern, Central and Western Asia and has remained almost constant in the Eastern Asia.

2.2 Milk Production and Productivity

As per the FAO statistics, in 2013 Asia contributed 38% to world's milk production: Asian countries together produced 292.4 million tonnes of milk against the global production of 768.6 million tonnes. About 95% of the milk production was contributed by cattle and buffaloes and the remaining by other species. In the last two decades, the milk production increased at an annual rate of about 4percent in Asia against 1.9% globally.

The Asian countries together in 2013 had 105.9 million milk cows comprising 39% of world's cows in milk and 59.3 million milk buffaloes consisting of 97% of world's buffaloes in milk (See Table 2). The contribution of Asian cows to total cow milk production was about 28% and that of buffaloes to total buffalo milk production was 97%. Although, the average yield of cows in Asia was 1676 kgs. compared to the global average of 2347 kgs., the rate of growth in productivity in Asian cows was almost four times the global average.

Table 2: In milk, Productivity and Production of Cattle and Buffaloes

Region	Cattle				Buffaloes			
	1993	2003	2013	CAGR	1993	2003	2013	CAGR
In Milk Animal (in million)								
South Asia	44.72	53.24	68.75	2.17	33.98	41.85	53.12	2.26
South Eastern Asia	1.76	2.32	4.09	4.30	0.28	0.34	0.61	3.99
Eastern Asia	5.90	9.20	14.11	4.46	4.60	5.40	5.45	0.85
Central Asia	7.27	6.30	8.96	1.05	0.00	0.00	0.00	
Western Asia	8.59	8.43	9.97	0.75	0.16	0.16	0.10	-2.69
Total Asia	68.24	79.48	105.87	2.22	39.02	47.74	59.27	2.11
% to total World	30.94	34.24	39.09		96.10	96.45	96.79	
Total World	220.54	232.15	270.85	1.03	40.60	49.50	61.24	2.08
Yield per Animal per year (in kgs)								
South Asia	767	959	1229	2.39	1301	1618	1802	1.64
South Eastern Asia	618	934	989	2.38	468	558	577	1.05
Eastern Asia	2724	3148	3243	0.87	444	509	560	1.17
Central Asia	1540	1811	1903	1.06	0	0	0	
Western Asia	1554	1918	2625	2.66	952	923	1016	0.32
Total Asia	1113	1381	1676	2.07	1193	1482	1674	1.71
% to total World	53.22	61.68	71.44		100.51	99.82	100.46	
Total World	2092	2239	2347	0.58	1187	1485	1666	1.71
Total Milk Production per year (million tonnes)								
South Asia	34.28	51.07	84.47	4.61	44.22	67.69	95.73	3.94
South Eastern Asia	1.09	2.16	4.04	6.78	0.13	0.19	0.35	5.09
Eastern Asia	16.07	28.97	45.75	5.37	2.04	2.75	3.05	2.03
Central Asia	11.19	11.40	17.04	2.12	0.00	0.00	0.00	
Western Asia	13.35	16.16	26.18	3.42	0.16	0.15	0.10	-2.37
Total Asia	75.98	109.77	177.48	4.33	46.55	70.78	99.22	3.86
% to total World	16.47	21.12	27.92		96.59	96.29	97.24	
Total World	461.39	519.79	635.58	1.61	48.19	73.50	102.04	3.82

Source:FAOSTAT

Among Asian countries, South Asian countries contribute maximum to milk production: in 2013 they had 65% of milk cows and 90% of milk buffaloes and produced some 65% of the total cow and buffalo milk. The second highest contribution was from East Asia: in 2013 the countries in Eastern Asia had 13% of cows and 9% of buffaloes and produced about 18% of the total cow and buffalo milk. The contribution of the South Eastern Asia was the lowest among other Asian regions: in 2013 these countries together had 3.8% cows in milk and 1% buffaloes in milk and produced about 1.6% of the total cow and buffalo milk production.

There is a vast variation in the number of cows and buffaloes and their yields among Asian countries (See Table 3). India has the largest populations of cattle and buffaloes and is the largest producer of milk in the world. One can categorise the countries based on the number of animals and yields (See Table 4).

Table 3: Number, productivity and production in Asian countries (Year 2013)

Country	Animals in Milk - cows	Yield/ Head in kgs.-cows	Production in tonnes - cow	Animals in Milk buffaloes	Yield/ Head in kgs-buffalo	Production in tonnes - buffalo	Production in tonnes - cows + Buffalo	Total Milk Production in tonnes
South Asia:								
Afghanistan	4E+06	370	1495600				1495600	1835200
Bangladesh	4E+06	206	838000	95000	411	39000	877000	3531150
Bhutan	150000	257	38550	210	400	84	38634	38634
India	4E+07	1350	60600000	38900000	1800	70000000	1,31E+08	1,4E+08
Iran	3E+06	2317	6850000	63000	1031	65000	6915000	7612850
Nepal	1E+06	480	492379	1369796	868	1188433	1680812	1770212
Pakistan	1E+07	1230	13897000	12595000	1935	24370000	38267000	3,9E+07
Sri Lanka	299440	848	254000	98950	657	65000	319000	324805
South East:								
Cambodia	138000	170	23460				23460	23460
Indonesia	636000	1543	981588				981588	1388138
Lao People's Democratic Republic	36000	200	7200				7200	7200
Malaysia	155000	512	79350	6160	1461	9000	88350	88350
Myanmar	3E+06	531	1380000	568000	544	309000	1689000	1708010
Philippines	5500	3551	19530	4884	1342	6556	26086	26086
Thailand	365000	3000	1095000				1095000	1095000
Viet Nam	152000	3003	456400	31000	1000	31000	487400	487400
East Asia:								
China, mainland	1E+07	2918	35310000	5450000	560	3050000	38360000	4E+07
China, Taiwan Province of	59145	6087	360000				360000	376500
Democratic People's Republic of Korea	42000	2333	98000				98000	98000
Japan	992100	7568	7508261				7508261	7508261
Mongolia	710000	536	380830				380830	509746
Republic of Korea	206000	10160	2093000				2093000	2096905

However, for big countries like India, China and Pakistan, the average yields may not reflect the true picture as there are large variations in yields within these countries.

Table 4: Categorization of countries based on number of animals in milk and their yields

	A. Cattle				**B. Buffaloes**			
Population	**Yield (in kgs.)**				**Yield (in kgs.)**			
	< 1000	**1000-2000**	**2000-4000**	**> 4000**	**< 500**	**500-1000**	**1000-1500**	**> 1500**
> 10 million		India	China Main					India
		Pakistan						Pakistan
1-10 million	Afghanistan		Iran	Japan	China	Nepal		
	Bangladesh							
	Nepal							
	Myanamar							
< 1 million	Bhutan	Indonesia	Thailand	Taiwan	Bangladesh	Srilanka	Iran	
	Sri Lanka		Korea		Bhutan	Philippines	Malaysia	
	Cambodia		Vietnam			Vietnam		
	Lao		Philippines			Mynamar		
	Malaysia							
	Mongolia							

2.3. Breeds of cattle and buffaloes

There are many local breeds of cattle and buffaloes particularly in India and Pakistan that are well adapted to local environmental conditions and have potential to produce milk comparable to any other exotic breeds or their crosses under tropical conditions. Table 5 lists the potential dairy breeds of cattle and buffaloes maintained by farmers in Asian countries. Many local cows have been crossed with exotic breeds like Holstein Friesian, Jersey, Brown Swiss, etc. as well as with some of the Asian breeds like Sahiwal, Red Sindhi, Gir, Hariana, etc. Many local buffaloes have also been crossed with Murrah and Nili Ravi breeds of buffaloes in many Asian countries.

Table 5: List of potential dairy breeds of cattle and buffalo in Asia

Region	Cattle breeds	Buffalo breeds
South Asia	Gir, Sahiwal, Red Sindhi, Rathi, Kankrej, Hariana, Tharparkar,Ongole, Krishna Valley, Siri, Cholistani, Red Chittagong	Riverine: Murrah, Nili Ravi, Mehasana, Surthi, Toda, Jaffarabadi, Banni, Kundhi, Pandharpuri, Bhadawari,
South East Asia	Bali, Madura, Pesisir, Aceh	Swamp buffaloes, Carabao
East Asia	Chinese Holstein, Chinese Simmental, Xinjiang Brown, Sanhe, Holstein, Jersey, Simmental,	Swamp buffaloes: Binglangjiang, Binhu, Xinyang, Enshi, Fuan, Guizhou, Fuling, Dehong, Diandong

3.0 Production Systems and Institutional Infrastructure

This chapter describes the dairy production systems and the supportive institutional infrastructure for implementing genetic improvement activities in Asia.

3.1 Production systems

A very large variation exists in dairy production systems in Asia. Taking the classification of livestock production systems of Sere and Steinfeld (FAO, 1996) and adding the dimension of smallholder dairy production, the Asian Dairy production systems can be classified as depicted in Figure 1.

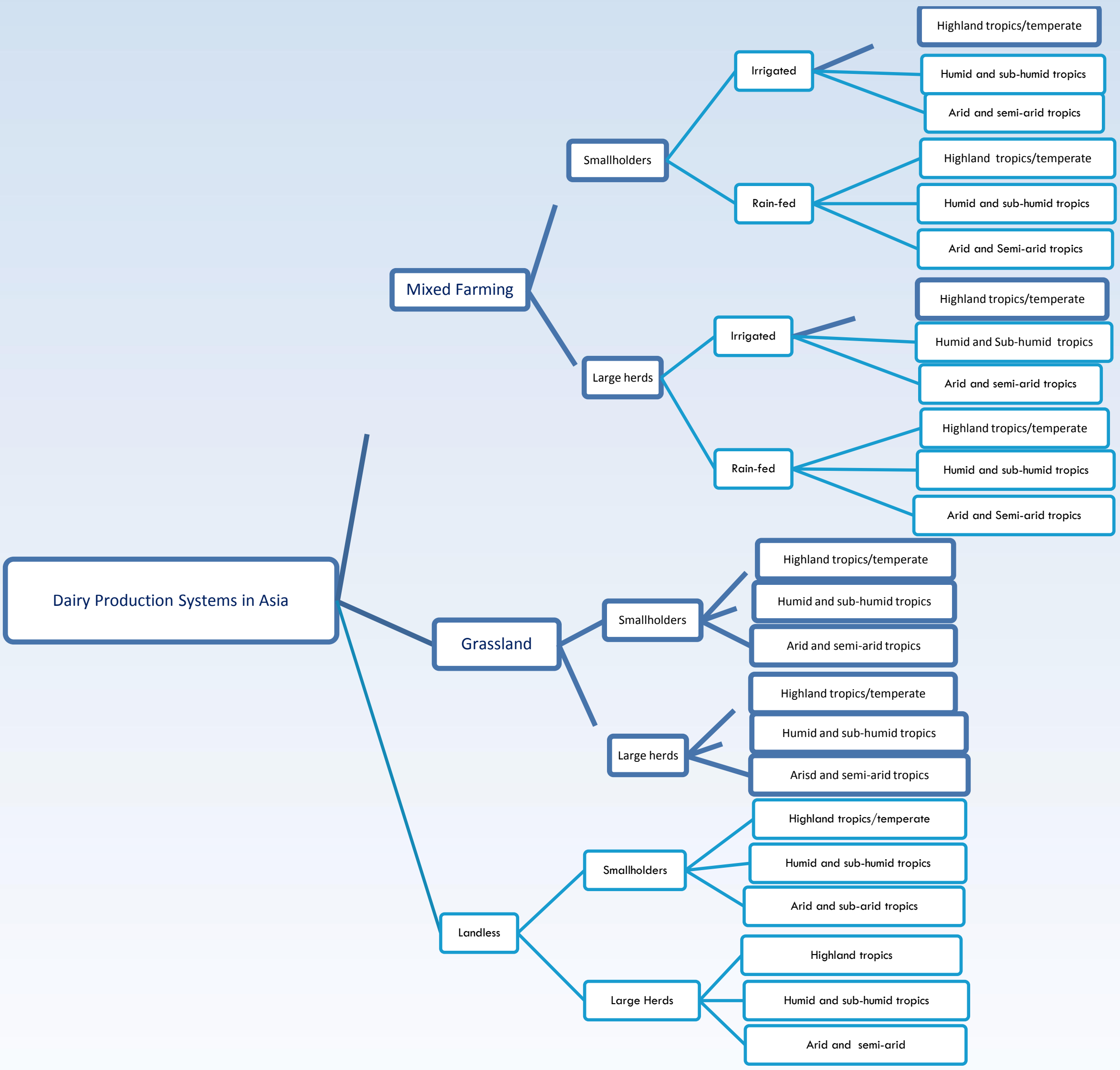

Figure 1: Dairy Production Systems in Asia

All dairy production systems in Asia can be grouped first into three broad groups: mixed farming systems, grassland systems and landless dairy production systems. Mixed farming system implies that at least some percentage of feed and fodder inputs comes from crop-based agriculture; grassland system implies that crop-based agriculture is minimal, and landless dairy production system implies that all required feed and forages are purchased. Mixed farming, grassland and landless dairy production systems could be further grouped into two classes: one smallholder system (having say less than 10 cows and buffaloes) and another large herd system (having more than say 10 cows and buffaloes). Mixed farming systems, both small and large herds, could be grouped into rain-fed systems and irrigated systems and further both rain-fed and irrigated systems could be subdivided based on agro-ecology into three groups: highland tropical/temperate, humid/semi-humid tropical or arid/ semi-arid tropical. Likewise, both grassland and landless dairy production systems could be grouped further into smallholder and large herds and both of them could be further subdivided based on agro-ecology into three groups: highland tropical/temperate, humid/semi-humid tropical and arid/semi-arid tropical. Smallholders in many Asian countries have formed cooperatives to collect, process and sale their produce particularly in India. Some examples of Asian dairy production systems are given below:

1. **Mixed Farming Smallholder Temperate/Highland tropical Rain-fed or Irrigated dairy production systems**: These systems are typically found in Eastern Asia, Northern highlands areas in India, and North-western highland areas of Pakistan. In Eastern Asia typically dairy farmers keep pure Holstein animals, whereas those in highlands area of Northern India and North-western area of Pakistan keep both local and crossbreds cows.

2. **Mixed Farming Smallholder Arid/Semi-arid Rain-fed or Irrigated dairy production systems:** In Asia milk production is concentrated in these production systems of India and Pakistan and account for more than 90 % of the total Asian milk production. Milk production comes from both cows and buffaloes. These systems are also found in North-eastern Thailand and Eastern Indonesia.

3. **Mixed Farming Large herd Arid/Semi-arid irrigated dairy production systems:** Many progressive areas of Asia having tradition of high milk production such as Punjab state in India, Punjab province in Pakistan dairy farmers are increasing their herd sizes and many mixed farming large dairy herds are coming up.

4. **Mixed Farming smallholder humid/semi-humid rain-fed or irrigated dairy production systems**: Typical cases of these systems are found in Southeast Asian countries – Thailand, Indonesia, Malaysia, the Philippines, and Vietnam. Dairy farmers in these regions keep both cows and buffaloes.

5. **Grassland dairy production:** An example of this system is found in temperate pastoral region of highland in the province of Heilonjiang and Inner Mongolia in China which are the top two largest milk producing regions of the country. Chinese Holstein and Sanhe cattle are reared by farmers in these regions. Most of them are small farmers having less than 10 animals.

6. **Landless large herds**: These systems are found around large cities in India and Pakistan such as Mumbai and Karachi. Herd sizes range from 50 to 1000 cattle and buffaloes, mostly buffaloes. Female animals in second or third lactation either close to calving or with calf at foot are purchased often from distanced villages having best animals. After completion of lactation, lasting 250-300 days, these animals are either slaughtered or sent back to villages. Though many animals are not mated, with the acceptance of AI, increasing numbers of animals are now getting inseminated. Large herds in peri-urban areas of Beijing, Tianjin and Shanghai also represent typical landless large herd dairy production systems. These farms are either owned privately or by a township or by a commune. They buy all their requirement of feeds and fodder and sell their produce. Large herds are also found around large cities in Thailand.

7. **Landless smallholder production systems:** In this case farmers have no land. They keep 1 to 5 animals. Animals are herded by a family member

along road side or in communal grazing land for grazing. They may also cut and carry forages when available. Some 20 % of rural households in India may fall in this category having about 3 % of milch animals. They keep mostly local animals, but some also keep crossbreds. Herd size is usually less than five animals. Tea plantation workers keeping 1-3 high producing milch animals mostly of pure Holstein Friesian breed in Hill country region of Sri Lanka is another example of landless small dairy production system.

3.2 Institutional Infrastructure

As the data on institutional infrastructure for genetic evaluation of animals and dissemination of genetics in Asian countries is not readily available, a simple questionnaire was designed to collect the required data. The questionnaire was sent to fifteen countries (the questionnaire designed is given at Annex I). Replies were received from six countries, namely China, Indonesia, Thailand, Afghanistan, Bhutan and India. The analysis of the data received from these countries is presented in this section.

3.2.1 Population and Productivity

The data on total cattle and buffaloes, number of animals in milk, average milk yields and total milk production of the six countries are given in Table 6.

Comparatively, India has a very large population of cows in milk. Dairy cows in China, though relatively less, their number has increased at an annual rate of 6-7 % in the last three decades (FAOSTAT).

Indonesia and Thailand, like other countries in Southeast Asia, have relatively less dairy cows. Some 30 % of dairy cows in India and about 36 % in Bhutan are crossbred cows primarily Holstein and Jersey crosses. About 90 % of dairy cows in China and almost the majority of dairy cows in Thailand are Holstein crosses (J.X. Liu et al, 2001; S. Tumwasorn, 2014). The productivity of dairy cows in China and Thailand is high compared to that in India, Afghanistan, Bhutan, and Indonesia.

India and China have large buffalo populations. China has both Swamp and Riverine buffaloes, whereas India has only Riverine buffaloes. In India, the contribution of buffaloes to total milk production is about 51%, whereas in

China it is negligible. The average productivity of buffaloes in China is 3.5 kgs. per day, whereas in India 4.9 kgs.

Table 6: Population and Productivity

Species	China	Indonesia	Thailand	Afghanistan	Bhutan	India
Cattle:						
Total Cattle	15,000,000	15,494,288	4,916,632	3,720,000	302,504	190,904,000
In milk animals:						
Local	5,000,000		235,829		41,985	31,035,490
Exotic/CB	1,000,000				22,770	13,755,770
Total in milk	6,000,000	28,452	509,524	2,100,000	64,755	44,791,260
Yield:						
Local	16.0			3	1	2.5
Exotic/CB	23.0			10.0	4.2	6.78
Average Yield Cattle	17.2	9.0	12.53	6.0	2.1	3.8
Total Production:						
Local	29,200,000				8817	28,306,220
Exotic/CB	8,350,000				25,931	33,888,650
Total Production Cattle	37,550,000	3143	1,115,791	1,502,000	34,748	62,194,870
Buffaloes:						
Total Buffaloes	20,000,000		888,431		574	108,702,000
In milk animals	150,000				112	39,286,200
Yield	3-4				2.5	4.91
Production	22800				58.8	70,442,620
Total Milk Cows + buffaloes	**37,572,800**	**3143**	**1,115,791**	**1,502,000**	**34,806**	**132,637,490**

Table 7 shows the trends of cattle and buffalo populations in the six countries.

Table 7: Trends of cattle and buffalo population

Trend	China	Indonesia	Thailand	Afghanistan	Bhutan	India
Cattle:						
Local:						
Increasing			√	√		
Steady						
Declining	√	√			√	√
Exotic/CB:						
Increasing	√	√	√	√	√	√
Steady						
Declining						
Buffaloes:						
Local:						
Increasing						√
Steady						
Declining	√	√			√	
Exotic/CB:						
Increasing	√					
Steady						
Declining						

As reported in the questionnaires received, the local cattle populations have been declining (except in Afghanistan; the local population in Thailand is Thai HF), whereas that of crossbreds/Exotic cattle has been increasing. In India, the buffalo population has been increasing steadily, whereas in China and Bhutan it has been declining. In China, the exotic and crossbred buffalo populations have been steadily increasing.

3.2.2 Breeds of Cattle and buffaloes

The list of cattle and buffalo breeds provided by the respondents is given in Table 8. There are many local breeds of cattle in Asian countries. In most of the countries, they have been replaced steadily by crossbreds/Exotic cattle.

Table 8: List of cattle and buffalo breeds

Country	Cattle			Buffalo		
	Local	**Exotic**	**Cross-bred**	**Local**	**Exotic**	**Cross-bred**
China	Xinjiang Brown Sanhe	Holstein, Simmental, Jersey	Chinese Holstein, Chinese Simmental	Swamp - Binglangjiang	Murrah Nili Ravi	Swamp and Riverine CB
Indonesia	Bali, Sumba Ongole, Madura, Pesisir, Aceh, Sumbawa, Jabres, Donggala, Pasundan, Kuantan, PO Kebumen	Holstein, Limousin Simmental	Simmental CB, Limousin CB, Brahman, HF CB	Swamp buffalo breeds - Simuel, Pampangan, Sumbawa, Moa, Toraya, Kalimantan Timur, Kalimantan Selatan	Murrah Nili Ravi	Swamp and Riverine CB
Thailand		Holstein	Thailand HF			
Afghanis-tan	Sistani, Kandhari, Kunari	Holstein, Brown Swiss, Mont-beliarde				
Bhutan	Nublang, Yangkum, Doebam, Doethra, Jaba	Jersey, Brown Swiss,	Jersey CB, Brown Swiss CB, HF CB			

India	Sahiwal, Gir, Red Sindhi, Rathi, Kankrej, Hariana, Tharparkar, Ongole, Krishna Valley, Deoni	Holstein, Jersey	Holstein CB, Jersey CB, Brown Swiss CB	Riverine buffalo breeds - Murrah, Mehsana Jaffarabadi, Banni, Surti, Pandharpuri, Nili Ravi, Toda, Bhadawari.		

Their population to total cattle is small and has been declining gradually as indicated in Table 7. In South Asian countries, the majority of buffaloes are Riverine, while that in Southeast and Eastern Asian countries they are Swamp. The populations of crossbred buffaloes (Swamp X Riverine) and pure Riverine buffaloes have been increasing in China and other Southeast and Eastern countries.

3.2.3 Semen stations and semen production:

Table 9 provides the details of number of semen stations and number of semen doses produced, and Table 10 provides the details of doses produced species wise in the six countries. All six countries produce semen doses. The largest production of semen doses is in India - about 97 million per year, which is also the highest in the world. China is the second largest semen dose producing country in Asia. Indonesia produces 7.8 million; the other three countries produce less than 1 million doses per year. The government plays a major role in five of the six countries other than in China; 75% of 85 semen stations in the five countries are owned by governments. In India cooperatives and non-government organisations also play an equal role in semen production. There are 8 semen stations in the cooperative sectors and four in the NGO sector; together they produce some 47% of semen doses in the country. Sabarmati Ashram Gaushala, a trust, managed by NDDB, in 2014-15 produced about 15 million doses, which is the highest semen producing station in the world.

In the six countries, 75% of semen doses produced is that of cattle breeds and the rest 25% of buffalo breeds. Of the total 97 million cattle semen doses produced by these countries, 32.2% is that of local breeds, 42.2% of exotic breeds and 25.6% of crossbreds. India is the major buffalo semen producing country in the world. In 2014-15, it produced 31.5 million doses.

Table 9: Semen stations and semen production

Institution	China	Indonesia	Thailand	Afgha-nistan	Bhutan	India
Semen Stations:						
Government	2	18	7	1	1	37
Cooperative			1			8
NGO/trust			1			4
National Private						2
International Pvt.						
Others	44		5			
Total	46	18	14	1	1	51
Doses produced:						
Government	1,500,000	7,800,000	988,691	100,000	10,189	48,262,830
Cooperative						15,165,950
NGO/Trust						30,709,500
National Private						2,979,140
Others	23,000,000					
Total	24,500,000	7,800,000	988,691	100,000	10,189	97,117,420

Table 10: Semen production species wise

Species	China	Indo-nesia	Thailand	Afgha-nistan	Bhutan	India
Cattle:						
Local	20,000,000	259,853			3327	10,945,832
Exotic	3,000,000	7,069,054	456,278	100,000	6862	30,316,661
Cross-bred			524,675			24,361,182
Buffa-loes:						
Local	600,000					31,493,744
Exotic	900,000					
Total	24,500,000	7,328,907	980,953	100,000	10,189	97,117,419

All six countries import a small number of semen doses (less than 0.5 million doses) from the US, Canada, Europe, Australia and New Zealand.

3.2.4 Infrastructure for AI delivery

India has the largest AI network; there are some 100 thousand AI centres carrying out about 65 million AIs across the country. China has 7250 AI centres carrying out 5.8 million AIs and Indonesia having 2215 AI centres carrying out some 1.6 million inseminations. Thailand has 746 AI centres doing some 263 thousand AIs. About 60% of AI centres in these six countries are in the government sector, 16% in the cooperative sector, 8% in the NGO sector and 16% in the private sector. The number of breedable animals inseminated is 95%, 60% and 27% in China, Indonesia and India respectively.

Table 11: AI infrastructure

Particulars	China	Indo-nesia	Thailand	Afgha-nistan	Bhutan	India
No. of AI Centres	7250	2215	746	518	144	103,580
No. of AI	5,800,000	1,600,000	263,000	NA	8,247	65,320,000
% of animals Inseminated	95%	60%	NA	NA	NA	27%

3.2.5 Genetic Evaluation

China, Thailand and India have been implementing progeny testing programmes. Dairy Association of China has been implementing a progeny testing programme in Chinese Holstein since 1983. NDDB in India, in collaboration with a select dairy cooperative unions and federations, livestock development boards and NGOs, has put in place 13 progeny testing programmes in five breeds namely pure Holstein Friesian, Holstein Friesian crossbreds, Jersey crossbreds, Murrah buffaloes and Mehsana buffaloes under its National Dairy Plan beginning 2010; three of these programmes have been in operation now for more than three decades. In Thailand, progeny testing of the Thai Holstein started in 1979 with the first sire summary published in 1987.

Table 12 summarizes the involvement of different institutions and the funding support received for genetic evaluation and associated activities. In all six countries the involvement of government in genetic evaluation and associated activities is high except in Afghanistan where it is absent and in Bhutan it is low. The involvement of cooperatives is rated as "medium" except in India where it is rated as "high" and in Bhutan as "low". Private sector is also involved in China, Indonesia and Thailand. Funding support received for genetic evaluation and associated activities are primarily from government in all six countries. Cooperatives have also been contributing in Indonesia, Afghanistan, Bhutan and India. In India a couple of NGOs are actively involved and supporting genetic evaluation and associated activities.

Table 12: Involvement and funding support

Country		Govern-ment	Coopera-tives	NGOs	Private Local	Pvt. Inter-national
China	Involvement	H	M		M	
	Funding	√				
Indonesia	Involvement	H	M		M	L
	Funding	√	√			
Thailand	Involvement	H	M		M	
	Funding	√				
Afgha-nistan	Involvement		M			
	Funding		√	√		
Bhutan	Involvement	L	L	L	L	L
	Funding	√	√			
India	Involvement	H	H	H		
	Funding	H	M	M		

Note: H-High; M- Medium; L – low; √ - Yes

3.2.6 Data collection and dissemination of information

Varied levels of computerized systems are used for managing semen production, AI and genetic improvement programmes in all six countries (See Table 13). There are no details on the kind of computerised systems used in the six countries. In general, however, all countries are using centralised systems for genetic improvement programmes. For AI, all have decentralised systems, except in India and Bhutan, where some centralisation has been attempted. Semen production systems are generally de-centralised except in Bhutan where they have a centralised system and in Afghanistan where they have a manual system. In Thailand and India some attempts have been made to aggregate semen production data centrally.

Table 13: Data collection and dissemination of information

	China	Indonesia	Thailand	Afghanistan	Bhutan	India
Semen Production:						
Manual				√		
Computerised:						
Decentralised	√	√	√			√
Centralised			√		√	√
AI:						
Manual						
Computerised:						
Decentralised	√	√	√	√	√	√
Centralised			√		√	
Genetic Improvement:						
Manual						
Computerised:						
Decentralised				√		
Centralised	√	√	√		√	√

Note: √ - Yes

3.2.7 Training and Research facilities

As reported by respondents, training facilities for AI is "good" in all countries except in Afghanistan, where it is rated as "medium" (See Table 14). Likewise, good training facilities are available for semen production and processing in all countries except Afghanistan. Training facilities both for genetic improvement and information systems are rated "good" in Thailand and India, "medium" in China, Indonesia and Bhutan ("Low" for genetic improvement). Afghanistan has reported that they do not have training facilities for both genetic improvement and information systems.

With regard to research facilities, both Afghanistan and Bhutan have reported that they have "low" facilities in all four areas. On the other hand, both Thailand and India have stated that they have "good" facilities of research in all four areas, except Thailand reporting research facilities for information systems as "medium". Indonesia has reported that they have "good" research facilities in semen production and AI and "medium" facilities in genetic improvement and information systems, whereas China has reported that they have "good" research facilities in AI, but "medium" facilities in semen production, genetic improvement and information systems.

Table 14: Training and Research facilities

	China	Indonesia	Thailand	Afghanistan	Bhutan	India
Training:						
Semen Production	G	G	G	N	M	G
AI	G	G	G	M	G	G
Genetic Improvement	M	M	G	N	L	G
Information Systems	M	M	G	N	M	G
Research:						
Semen Production	M	G	G	L	L	G
AI	G	G	G	L	L	G
Genetic Improvement	M	M	G	L	L	G
Information Systems	M	M	M	L	L	G

Note: G – Good; M - Medium; L - Low; N – None

3.2.8 Other information

The questionnaire also sought comments and suggestions in the following five matters. The responses received from the respondents are summarized below:

1. **Constraints faced:**

China: Performance recording system (DHI) is limited

Bhutan: Inadequate competency in carrying out the Genetic improvement programme; Poor recording and reporting system especially from the backyard farming units.

Afghanistan: Inadequate technical staff, unavailability of improved bull semen, insecurity, uncoordinated breeding programmes, importation of poor quality semen straws, poor record keeping, no genetic evaluation programmes, no research and training stations.

Indonesia:	Continuity of individual animal recording data at farmers' level, cooperatives and private institutions.
Thailand:	Quality of data collection by smallholder dairy farmers (for example: AI history, semen used, etc.) resulting in inadequate data for genetic evaluation and selection.
India:	Limited AI constraining expansion of progeny testing programmes; continuity of funding support.

2. **Priority areas:**

China:	Beijing, Shanghai, Shangdong province, and Hebei province are the priority areas for genetic improvement.
Bhutan:	Capacity development for systemic monitoring and implementation of genetic improvement programmes; establishment of institution for proper recording and evaluation system at the farm level.
Afghanistan:	Assessment of current breeding programmes and recording of production traits of existing livestock breeds.
Indonesia :	Progeny testing to continue
India:	Expanding exiting progeny testing and pedigree selection programmes; initiating progeny testing programmes for important dairy cattle breeds like Gir, Sahiwal, Rathi and Kankrej and important buffalo breeds like Jaffrabadi and Nili Ravi; introducing genomic selection procedures under existing genetic improvement programmes

3. **Key interventions required:**

China:	Bull stations and DHI centers carry out combined breeding of dairy cattle together with core cattle farms. The cattle farms need to raise awareness of DHI and intensive collection and management of breeding data.
Bhutan:	Capacity development and software for collection and dissemination of information.
Afghanistan:	Establishment of regional bull stations and semen processing laboratories, increased funding for breeding programmes, capacity development of technical staff, introduction of coordinated breeding programmes,

	importation of quality bull semen straws, livestock census, livestock identification (and tracing) systems for breeding cows and bulls.
Indonesia:	Training for animal recording and managing and analyzing data.
India:	Developing an infrastructure for recording for animal type traits; setting up genotyping and bio-informatics facilities; establishing a few nucleus herds with ET and IVF facilities for indigenous breeds.

4. **Policy and regulatory framework required:**

China:	The Ministry of Agriculture provides a certain subsidy for cattle breeding purposes at present such as subsidies for importation of high quality embryo and elite cows, etc.; such subsidy needs to be continued.
Bhutan:	Genetic Improvement of local breeds through cross breeding and development of breeds that could perform well under local environment and farming system.
Afghanistan:	Breeding policy and regulatory framework and strategic planning.
Indonesia:	Recognition by policy makers that national genetic improvement programme is never ending programme; de-centralisation of genetic improvement programme such as an open nucleus breeding programme in the center production area.
India:	Adherence to state breeding policy; enacting a law and its enforcement for registration of bulls, semen stations, AI technicians, AI delivery organizations, and AI training centres.

5. **Expectation from Dairy Asia Platform:**

China:	Share international dairy information with China; Technical backstopping of genetic improvement programmes.
Bhutan:	Facilitate sharing of Germplasm among Asian Countries; Enhance capacity of technical people to implement the Genetic improvement programmes through proper

recording and analysis of data; Support establishment of MOET technology to expedite genetic improvement programme.

Afghanistan: Train technical staff; access to quality improved bull semen and establish information systems.

Indonesia: Provide exchange/share and update information on dairying in the region and collaborate having a dairy consortium research for genetic improvement in each country.

India: Prepare standard operating procedures for genetic improvement programmes under smallholder production systems; standardise breeding value estimation procedures under smallholder production systems; share information; organise training programmes; facilitate making available experts.

4.0 BREEDING STRATEGIES FOR DEVELOPING EFFECTIVE AND SUSTAINED BREEDING PROGRAMMES

Dairy farmers desire to have animals that can be fed and managed for economically optimal production in their existing agro-climatic conditions. They also desire to raise gradually the genetic potential of their animals and thereby the productivity of animals and their income. Planning efforts to improve dairy animals in any area therefore need to decide on two aspects: what kind of animals suit best in the given area, and how a steady genetic progress could be achieved in the targeted population. Broad guidelines have been provided in this section on these two aspects.

Initially the fact that climate change is now beginning to be considered as a major factor means that there are additional factors to be considered. Climate change may well provide a different environment from that experienced at present – the problem is trying to assess how much change will take place and whether existing breed abilities will cope with such changes. The Intergovernmental Panel on Climate Change (IPCC) makes it clear that fodder available will be more fibrous and that the yields of maize, soya and wheat are likely to reduce. This could be coupled to direct changes in temperature/ humidity.

Genetic improvement is relatively slow although additive, therefore, breed improvement programmes need to be considered in the light of requirements of some years ahead (present day requirements are not necessarily a good guide for future breeding goals). It is important that in designing breeding programmes the future needs of animals and farmers need very careful assessment. But present day requirements are most frequently used for setting breeding goals. These changes are predicted with a high degree of certainty and will have major consequences on choices of breeds and breeding goals for the future.

4.1 Choice of breed

Many big countries in Asia have a large variation in climate and in economic conditions of farmers. Climatic conditions greatly differ: temperatures may vary from minus 25°C in one part to as high as 40^0 C even in the same region let alone another; humidity may vary from below 10% in one region to above 95%

in another; and rainfall may vary from no rain at all to very heavy rainfall. Similarly, economic conditions of farmers may also vary greatly from very poor-resource farmers to very rich-resource farmers.

Farmers also follow different systems of breeding. The systems of breeding could be put into two main classes: One, selective breeding, and second, crossbreeding. Selective breeding implies that bulls and bull mothers used for producing future breeding and replacement stock are selected within breed, and crossbreeding, with local or exotic breed, implies that future breeding and replacement stock are produced through crossing of two breeds. And the resultant crossbred population is then further developed selectively, meaning bulls and bull mothers used for producing future breeding and replacement stock are selected within crossbred population. Alternatively, the resultant crossbred population is further crossed with either an exotic breed increasing the exotic inheritance in the crossbred population or backcrossed with a local breed reducing the exotic inheritance in the crossbred population. Some time when indigenous animals are crossed with local breeds, instead of referring it to as crossbreeding, it is often referred to as upgrading. And when animals are upgraded with local breeds, one is not bothered about the percentage of inheritance of local breed in the resultant upgraded population.

The choice of breed thus depends on the combination of climatic factors, resource level of farmers and farming systems followed by farmers as described above. One has to develop broad guidelines for breeding different categories of animals across many different agro-climatic conditions prevalent within a country. An approach provided in Annex II may be useful in deciding breeding policies for a country.

4.2 Building infrastructure for genetic improvement

Whether one chooses selective breeding strategy or crossbreeding, the genetic improvement of any breed of cattle or buffaloes involves the following steps:(i) defining a breeding goal for breed development - identifying traits that farmers would like to improve and giving weightage to each identified trait; (ii) developing an appropriate breeding structure for finding the best animals - developing an appropriate infrastructure to record the selected traits and identify those animals that have the highest breeding values for the traits included in the breeding goal; (iii) dissemination of superior genotype - developing an infrastructure to use the identified best animals to disseminate their superior genotype in the maximum number of animals in the target population; (iv) building information network to capture data and disseminate information to all stakeholders, and (v) putting in place systems of quality control for genetic evaluation and, where necessary, semen production, AI delivery and information systems.

4.2.1 Defining breeding goal

Defining breeding goals involves identifying traits that farmers would like to improve and assigning a goal value to each identified trait. In order to arrive at correct goal traits that farmers would like to improve, it may be necessary to look at first the development objective for which cattle and buffaloes are kept and to find out from farmers why they keep animals and what purpose it serves to them. Sometime religious sentiments dictate the choice of breed. For an example, in India, where cow slaughter is banned in many states, farmers prefer those breeds which have higher long-term productivity and higher life-time production. Not all information needed to follow the right procedure may be available. The important issue is to define the development objective in a given situation and arrive at breeding goals and then estimate goal values on available information. The genetic improvement programme could be initiated with the most important breeding goal and later with the information derived from the early implementation of the genetic improvement programme, the goals could be further refined.

4.2.2 Building infrastructure for genetic evaluation

The type of breeding programme that one can develop and the rate of genetic progress that one can achieve in a target population primarily depend on the extent of AI infrastructure available in the target population. Since with AI one can use top bulls more extensively in comparison to natural service and since in a large AI system, it becomes possible to put in place a progeny testing programme to produce much better quality bulls, the genetic progress that can be achieved under AI is always much higher than what could be achieved under natural service. A brief description of different breeding programmes that could be developed for the different levels of AI facilities is given below.

Progeny Testing (PT)

If very large numbers of villages in the target population have AI facilities, then progeny testing is a practical and the best option for achieving genetic improvement in any population. Here bulls are selected on the basis of their daughters' performance in the field. Since very high selection intensity can be applied on selection of sires and dams to produce the next generation of sires, and very high accuracy in selection of sires could be ensured with the production of a very large number of daughters of bulls, the genetic progress achieved under reasonably large progeny testing programmes is always much higher than other programmes.

A few institutions in Asia have initiated a progeny testing programme both in cattle and buffalo breeds with a varied level of successes. NDDB in India, in collaboration with a select dairy cooperative unions and federations, livestock development boards and NGOs, has put in place 13 progeny testing programmes in five breeds - three of these programmes have been in operation now for more than three decades (K. R. Trivedi, 2014). See Annex III for the standard operating procedures followed and the progress made under these programmes. In Pakistan, Research Centre for Conservation of Sahiwal Cattle (RCCSC), Jhang Livestock and Dairy Development Department, Government of the Punjab has been implementing a progeny testing programme in Sahiwal cattle since 1984 (Javed Iqbal, 2013), and Livestock Production and Research Institute in Nili Ravi buffaloes since 1979-80 (M. A. Khan and A. Ghaffar, 2007). Dairy Promotion Organisation in Thailand has been implementing a progeny testing programme in Thai Holstein since 1988 (S. Tumwasan, 2014). In the Philippines, Philippines Carabo Centre has been implementing a progeny testing programme in pure Riverine and crossbred (Riverine X Swamp) buffaloes (E. Flores, 2014).

The progeny testing programmes in Asian countries have not created significant impact on accelerating genetic progress in cattle and buffaloes because of their small scale of operation: First, the number of bulls put to test every year is very limited (10-40 bulls per year in different programmes against 400-1000 bulls per year under most efficient programmes) and therefore the intensity of selection applied both on sire-to-sire path and sire-to-dam paths are small; Second, the number of daughters used to estimate breeding values of bulls are small (30-70 per bull against 70-100 per bull in most efficient programmes) and hence the accuracy of selection both on sire-to-sire path and sire-to-dam paths are restricted, and Third, the intensity of selection applied on dam-to-sire path is also restricted because of limited number of animals put under recording. Expanding the scale of operation of progeny testing programmes is constrained by the limited coverage of animals under AI and the scattered and small herd sizes of participating farmers.

Implementers of progeny testing programmes in Asian countries also face many challenges because of peculiar nature of production systems and environmental constraints.

1. On an average more than 80% of dairy farmers in most of the Asian countries, and some time as high as 95% like in India and Pakistan, are small farmers having less than 5 dairy animals. It is always difficult to identify contemporary groups in such small herds. One can treat a village as a herd and produce daughters of as many bulls as possible within a village. It is often argued that farmers within a village learn from each other and often follow common management practices. But still one cannot compare a large herd with common management practices to a village – there will always be higher variation within a village than one can expect within a large herd. The issue is how one can improve breeding value estimation procedures in smallholder production systems. One may advise to focus on large herds, but that is impractical, as there are not many large herds.
2. Putting a very large number of bulls under test and using a small proportion of very best progeny tested bulls for AI to produce replacement heifers is also not practical in many Asian countries. Apart from limited number of animals inseminated, the other key reason is very high age at first calving in many Asian countries. Due to harsh environmental conditions and poor feed and fodder resources in many countries, the average age at first calving is very high particularly in buffaloes - 3 to 4 years. So by the time one gets progeny test results of bulls put to test, the bulls either no more exist or are too old (8-10 years) to be useful for semen production. In these circumstances one has to focus more on sire-to-sire and dam-to-sire paths to produce the next generation of bulls and do whatever best could be done on sire-to-dam path by selecting the best young bulls based on pedigree information for AI to

produce replacement heifers. One may argue this is not an optimal way. But that is the best one can do. In a situation where a very small number of bulls are put to test, it is observed that young bulls produce using semen of top quality progeny tested bulls and elite recorded dams may turn out to be genetically better bulls than progeny tested bulls produced six or seven years earlier. In a situation where pedigree selected young bulls, produced using top progeny tested semen and elite recorded dams, are used for AI, introduction of genomics for selection of young bulls would be very relevant.

3. Developing an infrastructure and a system for recording different traits in widely dispersed small dairy farms in harsh environmental conditions prevailing in many Asian countries are equally challenging. For example, developing a system of milk component analysis covering a few large dairy herds under ambient temperature below 25^0 C is one thing and developing the same system in well scattered large number of small dairy herds under an ambient temperature of 40-45^0 C is altogether a different thing. A centralised milk component laboratory, as commonly established in temperate climatic conditions, may not be feasible in many Asian countries having very harsh climatic conditions. A distributed milk component laboratory network will have to be considered under such conditions.
4. In a situation, where bulls for natural service exist along with AI service, ensuring correct parentage needs serious consideration. While all efforts may be made to remove or castrate bulls available for natural service in the project area, equal attention needs to be placed on building an infrastructure for parentage testing of certain percentage of randomly selected daughters born under progeny testing programmes.
5. In smallholder dairy production situations another serious problem is to convince dairy producers to participate in animal identification and recording systems. For a large dairy producer, it makes sense to participate in a recording system, as it will not be feasible for him to know about each and every cow. But a farmer, having one or two cows, knows everything about each cow. Any information system cannot add to what he knows. So sustaining the participation of smallholders in any recording system is always a real challenge. One has to think about finding information that is relevant to smallholders. Some immediate actionable

information preferably on their mobile such as this animal is expected to come in heat in next two days, this animal expected to calve in one week, this animal due for FMD vaccination, etc. could be very relevant to smallholders. Sometime one has to think of providing incentive to farmers for their participation at least in the beginning till they understand the importance of information.

Pedigree Selection

Here bulls are selected on the basis of their mothers' and sires' records and bull mothers are selected on the basis of their own records and their mothers' and sires' records. Many different programmes could be developed depending on the level of AI infrastructure available.

Nucleus Herd and village herds**:** A simplest breed improvement programmes in this category could be that an implementing agency establishes a herd of the breed to be improved. Selection is then carried out within the herd. Females are selected on the basis of their own performance and pedigree, whereas males are selected on the basis of pedigree. Males produced from the herd are sent in selected villages for natural service. This is the most common approach followed for breed improvement in many Asian countries.

The extent of genetic progress achieved in the target population through such programmes depends on the quality and number of bulls supplied for natural service every year. Number of bulls that the station can supply would depend on the herd size and the reproductive efficiency of the herd. The quality of bulls produced from the herd could be improved with increasing the herd size and employing AI and using only the top bulls to produce the males sent for natural service in the field. The quality of bulls could be further improved by having collaboration with other herds having the same breed. Associated herd testing programmes implemented jointly by the military farms, Indian Council of Agricultural Research and the Department of Animal Husbandry, Government of India is a classic example of this approach. Multiple Ovulation and Embryo Transfer (MOET) could also be employed to raise the selection intensity on the dam-sire path.

Nucleus herd, multiplier villages and target villages**:** In cases, where the number of males produced at the nucleus herd/s is not enough to meet the requirement, one more layer could be added in the programme. Here the top quality female animals are maintained in the nucleus herd/s. The bulls produced from the nucleus herds are used in multiplier herds (20-25 villages) to produce the required number of bulls for natural service in the target population. Thus, the best genetic material is transferred from the nucleus herd/s to the base population through multiplier herds. One variant to this approach could be that animals in multiplier villages are bred through AI for producing bulls for natural service in the base population reducing the requirement of males in multiplier villages (See Figure 2).

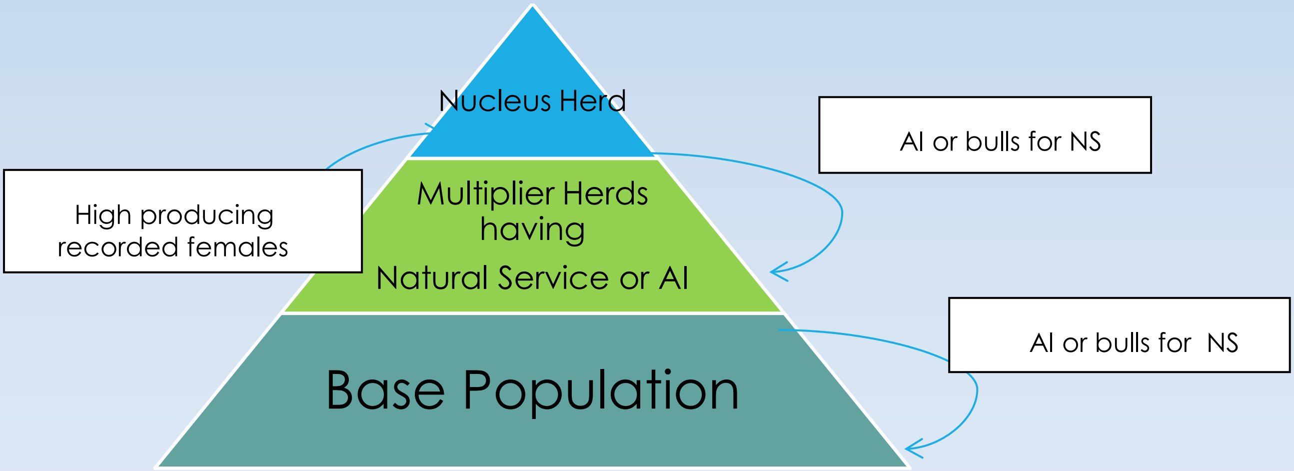

Figure 2: Three tier breeding structure

Multiplier villages and target villages: If one finds that some farmers have better animals than that can possibly be maintained at a nucleus herd, there may not be any need to maintain a nucleus herd and a two tier breeding structure could be evolved with top tier having AI facilities and implementing a bull selection programme with pedigree information and lower tier having natural service or AI (See Figure 3). All nine indigenous breed development programmes implemented by NDDB under their National Dairy Plan have followed such a two-tier breeding structure (www.nddb.coop).

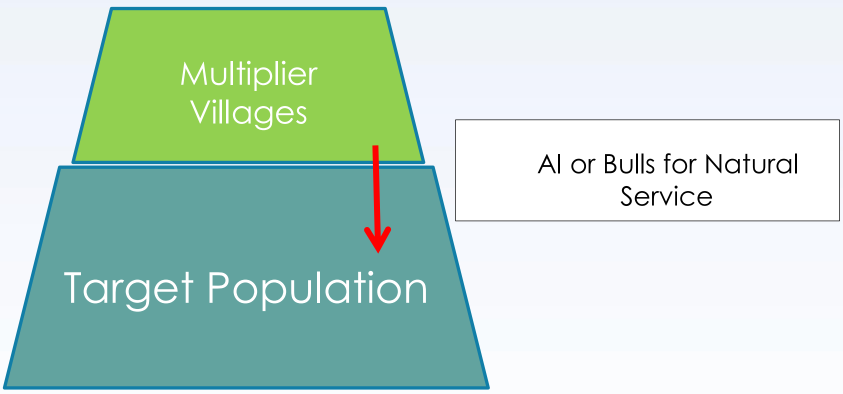

Figure 3: Two tier breeding structure

4.2.3 Building infrastructure for semen processing

Semen production and processing infrastructure is created to ensure that only the very best bulls produced through genetic improvement programmes are used for semen production and that the semen production and processing technologies are refined to produce increasing number of doses per bull with high sperm motility and no disease causing organisms. It is also necessary to adopt standard fertility prediction tests, as emerging evidences support the fact that only sperm motility is not enough to predict fertilizing ability of sperms. As semen production is a very specialized job, it is advisable to have a limited number of large capacity semen stations rather than a large number of small capacity semen stations. For ensuring quality of semen production, it is necessary to evolve a system of semen certification, which involves setting up minimum standards for production and processing of semen, developing a mechanism of evaluation of semen stations ensuring that the participating semen stations adhere to the standards set, andputting in place a system of certification of semen stations.

4.2.4 Dissemination of genetics

4.2.4.1 Establishing infrastructure for AI delivery

Once quality semen doses are produced using top quality bulls, they need to be carried to farmers' door-step to inseminate their animals. As AI coverage expands in any area, better quality genetics gets disseminated enhancing genetic progress in the population. Two areas need to be focused to provide effective AI delivery services in any area: one, building a liquid nitrogen (LN) and semen procurement and delivery system, and second, carrying out inseminations by trained AI technicians with quality semen without harming inseminated animals. Different organisations such as government, cooperatives, private breeding companies, non-government organisations provide AI services to farmers. These organizations manage LN and semen procurement and distribution and engage AI technicians to provide AI services to farmers. In addition, there are freelance private AI technicians who provide AI services to farmers. Two systems of LN delivery are prevalent: one, where each AI service provider manages its LN and semen distribution independently, and second, where service providers joint together in managing their LN procurement and distribution. Service Providing

Organisations can be financially self-sustainable if their AI technicians carry out certain minimum number of AIs and they charge AI services recovering their total cost of AI plus small margin of profit. Encouraging private sector to invest in providing AI delivery services could always be beneficial in the long run, and to do so equal playing field would need to be created by governments particularly by charging full cost of AI and putting in place an independent regulatory mechanism. In addition to building an infrastructure for LN and semen delivery, equally important is to build right AI technician training facilities to produced required trained AI technicians.

In majority of Asian countries, AI services are provided primarily by government AI centres or by AI centres of organizations contracted and monitored by government. In some countries, particularly in India, farmers' cooperatives also offer AI services. Besides government and cooperatives, in many countries NGOs and private organisations and many independent private AI technicians provide AI services. Among Asian countries the percentage of breedable animals inseminated varies from 10-90%.

4.2.4.2 Dissemination of genetics through natural service

While the use of Artificial Insemination allows the maximum use of the improved genotypes, there are circumstances where it is not economically viable to operate such a service. Where areas are isolated and farmers have very small numbers of animals and where the inseminator would not have sufficient regular numbers of animals to inseminate, the Conception Rates are likely to be very low. In such circumstances, natural service would be the only option. However, it should be clearly understood that using other methods of dissemination do not alter the rate of genetic change in the commercial population but simply alters the "Time Lag" between the improved and the commercial animals. The rate of progress after several generations is parallel to the nucleus – the different dissemination methods simply altering "Lag".

4.2.5 Developing an information network

Building an information network for capturing data at source, storing and processing data on a central computer, and generating and disseminating relevant information to all stakeholders is the key factor in successful implementation of any genetic improvement programme in any country. Building an information network comprises two set of activities: one, designing and developing an application, and second building an infrastructure for data capture, processing, storage, and generation and dissemination of information.

Any application developed for operating an integrated system has to be modular having modules for different functions such as animal identification and registration, performance recording, management and nutrition, health, traceability, statistical and analytical report, etc. It should also have an administrative module which handles all administrative functions such as creation of an organization and allowing organisations to select services/modules they want, defining hierarchy in an organization and assigning roles to different personnel in the organization, creating all masters required for operating the application, etc. The application should also have facilities to capture and validate data through different platforms such as smartphones, PDAs, netbooks, laptops, desktops, etc. It should provide information to various users – from the lowest level field force to the top level policy makers.

With regard to hardware, a central infrastructure needs to be set up to store data and provide web-based services. The main resources required include: a database server to host data; a web server to host web-based applications, and high speed connectivity. It should also have data backup and recovery services and should be well secured. There could be many ways to collect field data, they may include: (i) collecting data on paper and entering data through desktops/laptops and producing operating reports on desktops/ laptops; (ii) Entering data offline through smartphones/PDAs creating local database and synchronizing the local database with the central server periodically or entering data directly on smartphones/PDAs and updating the data online; (iii)Data exchange between the central server and other databases through XML files, and (iv) Web services for data exchange and limited access to produce information. The central database should then generate and provide information to all users - from field technicians at the lowest level to policy makers at the highest level through many different ways such as print output, fax, email, PDF files, HTML pages, mobile, PDA, etc. in various forms such as alert messages, operational reports, review reports, graphs, analytical reports, statistical summary reports, etc. The central database can also act as a data warehouse to extract any information on demand. For example, the data required for estimation of breeding values can be extracted from the central database and breeding values for bulls and animals under recording can be estimated. Data can be extracted from central database to prepare statistics on performance of different organizations and regions on production, reproduction, health, etc.

It should be mentioned here that animal identification forms the core component of any animal recording system designed for performance recording and genetic improvement and for that matter for many other purposes including traceability, animal health, insurance, paying subsidies to farmers, etc.

Not many Asian countries have developed an integrated information network. A notable example of an integrated information network developed is that by NDDB in India referred to as:" Information Network for Animal Productivity and Health (INAPH)". For a brief description on INAPH see Annex IV.

4.2.6 Putting in place systems of quality control

To maintain quality of implementation of breeding programme, it is important to set minimum standards, put in place an evaluation mechanism and certify bulls that are used for semen production or natural service, semen stations that produce and process semen doses, and AI service providers that provide AI services. A best way to ensure implementers of breeding activities adhere to minimum standards set is to establish an Independent Authority for registration, evaluation and certification of bulls, semen stations, AI service providers and AI training institutions, as done by many advanced dairy producing nations.

There are no formal and independent quality control systems in place for breeding activities in any Asian country.

4.3 Genetic improvement of local breeds

There are many local breeds of cattle and buffaloes in Asian countries as described in Section 2.3. These breeds of cattle and buffaloes have evolved and survived over many generations perhaps because of their remarkable traits such as adaptability to harsh climatic conditions, adaptability to survive and perform on poor quality feeds and fodders, adaptability to poor management conditions, resistance to diseases, etc. The other reason why these breeds have survived is their utility for several alternative uses in the existing agricultural practices and economic circumstances. For example, some cattle breeds in India like Kankrej, Haryana, Ongole, etc. have been selected for their draft qualities and adult males of these breeds still have very high market value.

The production conditions in which these breeds have been preferred are not likely to change in the near future. Harsh climatic conditions will continue and perhaps be more severe in the future. The increasing human population will not allow diversion of land from grain production to exclusively animal production and the animals will continue to be maintained on poor quality feed stuffs. The stress on animals caused by a variety of disease agents in Asian countries would also not diminish in the near future. Although, tractors have been replacing bullocks to some extent, the demand for bullocks for farm operations is not likely to go down very much. If the conditions are not likely to change, these breeds will be equally important to the farmers in the future.

The question which arises then is why the number of animals of some of these indigenous breeds has been declining at an alarming rate. One of the main reasons for the decline in number is that the economic returns to farmers from these breeds have been declining year after year as the productivity of these animals has not been increasing, while the cost of their maintenance has been steadily increasing. The solution to the problem therefore lies in the genetic improvement of these breeds. If systematic efforts are not taken to improve these breeds in the field, their number will further decline and eventually they will be lost forever.

It is imperative therefore that the cattle and buffalo breeds that are important in Asian countries are identified and systematic genetic improvement programmes are taken up for enhancing their productivity. The different approaches that could be applied for the genetic improvement of local breeds are well understood and tried as described in Section 4.2. Each country needs to identify local breeds that are important and develop appropriate genetic improvement programme for them. One may also think about importing animals of some local cattle and buffalo breeds that have performed well in some Asian countries, if local agro-climatic conditions are more or less similar to those under which the imported breeds are maintained.

4.3 Genetic improvement of crossbreds

Experiences of crossbreeding in tropical countries indicate that when local cows are bred with semen of superior exotic breeds like Holstein Friesian or Jersey, the resultant F_1 crossbreds produce two to three times more milk compared to local cows, provided they are fed optimally and protected and managed well. Hoping to produce more milk, farmers tend to increase further the exotic inheritance of their crossbreds by crossing F_1 crossbreds with pure exotic semen raising exotic inheritance to 75% in F_2 and further towards 100% in F_3 and subsequent generations. It has been observed in practice, however, that F_2 and subsequent generations generally do not produce more milk than F_1 generation, unless animals of F_2 and subsequent generations are provided optimal environmental conditions, fed to their requirement and protected well against diseases. It is observed that under average management conditions, animals of F_2 and subsequent generations generally do not produce more than that of F_1 generation.

From the experiment conducted in Brazil on different levels of exotic inheritance in crossbreds, it was observed that milk production increased as the level of inheritance increased till ½ of HF grade, both in low managed herds and high managed herds (milk doubled in ½ HF grade), however, milk production declined when HF inheritance increased beyond 50% in low managed herds. Whereas in high managed herds the milk production in HF grade beyond 50% remained almost constant or slightly increased. They concluded that European breeds may be utilized in more intensive production systems with no important climatic constraints, but are totally unfit for the harsher environments. For a wide range of environmental conditions, complementarities between highly productive and adapted breeds (1/2 HF grade) result in superior overall performance of crossbreds (F. E Madalena, 1987).

A strategy of maintaining exotic inheritance around 50% in the crossbreds and breeding them with selected *inter se mated* crossbred bulls obtained from progeny testing programmes may be the most ideal strategy for improving the productivity of crossbreds on a sustainable basis in average management conditions of most of Asian countries. Farmers with better resources may be advised to keep crossbreds with up to 75% exotic inheritance, but further grading up of crossbred beyond 75% exotic inheritance generally may not be advisable in most of the Asian countries.

The other problem with F_1 crossbred bulls is that more than 50% of crossbred cattle bulls procured by semen stations get culled for one or other reasons before they are used for extensive semen production. And when Swamp and Riverine buffalo are crossed almost 90% of F_1 bulls are sterile.

4.4 Keeping pure exotic animals and their further improvement

Many large herds that are coming up in several Asian countries start with having pure exotic animals like Holstein Friesian or Jersey. In conditions where temperature-humidity index is more than 72%, exotic animals do not produce to their potential even when they are fed well. In places where climatic conditions are favourable (temperature-humidity index < 72%) and farmers have pure exotic animals, such animals could be improved further by either using increasingly better quality imported semen or using exotic semen of locally produced bulls. A prudent strategy would be to put imported and locally produced bulls under test programme and based on the progeny test results decide on the use of semen of imported bulls or locally produced bulls. This needs also to consider reproductive traits, disease tolerance, etc.

5.0 RESEARCH AND DEVELOPMENT

Animal breeding and reproduction is very knowledge intensive and is constantly evolving. Genetic improvement programmes create a great impact on farm animal production as genetic gain is permanent and cumulative. As many important breeds of cattle and buffaloes in Asian countries have been excluded from any selection programme, there is a need to develop appropriate genetic improvement programmes for such breeds. For putting genetic improvement programmes in place, research efforts would need to be focused on breeding design, measurement of traits, data collection and management of information systems, breeding value estimation, etc. Recent introduction of whole genome selection procedures have revolutionized the way animals are being selected. For many Asian countries the introduction of genomics procedures would be very relevant and it would be in their interest to build knowledge on this emerging technology. On reproduction side, technologies like AI, ET, ovum pick up (OPU), and IVF are very important as they allow larger dissemination of improved genetics in the population. Building local knowledge and skills in these areas would be critical in achieving long term genetic gain. A few focus areas of research important to Asian countries have been highlighted in this chapter.

5.1 Designing and implementing genetic improvement programmes

Genetic progress per year depends on four factors: intensity of selection, accuracy of selection, genetic standard deviation and generation interval. The three of the four factors namely the intensity of selection, accuracy of selection and genetic standard deviation are positively related to genetic progress, whereas generation interval is negatively related. The aggregate genetic progress depends on how these four factors are applied on four paths namely: selection of sire to produce sires, selection of dams to produce sires, selection of sires to produce replacement heifers, and selection of dams to produce replacement heifers. Hence, while designing any genetic improvement programme one has to assess how the four factors would affect the genetic progress and how they could be manipulated to maximize the genetic progress. At the implementation level other important areas that need to be focused are: (i) Identifying traits to be included in breeding goal and assigning a goal value to each identified trait; (ii) Identification and registration of animals; a country not having past history of identification and registration would need some investigation on selection of appropriate tools and systems for identification of animals; and (iii) Standardization of methods for measurement of different traits and systems of quality checks.

5.2 Developing information systems for data collection and generation of information

Whether one decides to procure an application or develop a new application for data collection and generation and dissemination of information for animal breeding programmes, one has to define the scope of application, identify stakeholders, ascertain their information needs, and assess the existing IT infrastructure, technologies and resources. One has to then identify what data is to be collected, who collect the data and what information is to be generated for different stakeholders. Thus, putting in place an information system for any genetic improvement programme needs a thorough investigation.

5.3 Breeding value estimation under smallholder production systems

In a situation where dairy producers predominantly have small herds defining contemporary groups for unbiased estimation of breeding values becomes a real challenge. One possible option is to treat a village (or an AI unit) as a herd and produce daughters of as many bulls as possible within each village across all villages. In this situation, one expects to have a large variation in production within a village due to varying economic conditions and resource use by farmers compared to that in a large herd managed under common environmental and management conditions. One has to develop appropriate models to estimate breeding values in a situation where a village is considered as a herd.

5.4 Reducing culling of bulls and wastage of semen doses

More than 50% of crossbred cattle bulls procured by semen stations get culled for one or other reasons before they are used for extensive semen production. New technologies need to be developed to detect crossbred bulls that are not likely to be useful for semen processing very early in their life.
Likewise about 5-10% of ejaculations get discarded on account of law pre-freeze motility and other 3-5% doses are discarded on the basis of post-thaw

motility. Efforts need to be focused on developing better semen extenders and processing protocols to reduce discard during semen processing.

5.5 Introduction of whole genome selection procedures

Traditionally, animals have been selected for economically important quantitative traits based on phenotypic records of their own and their relatives. Since selection for bulls based on the performance of their daughters is found to be very accurate, a significant genetic progress has been achieved in many countries by implementing a progeny testing programme over a long period of time. With the advent of DNA chip technology, now it is feasible to genotype (called SNP typing – Single Nucleotide Polymorphisms) many animals for thousands of SNP loci. By genotyping large numbers of SNP markers (50,000-800,000 SNPs), it is now possible to estimate their effect on quantitative traits and use these estimates for arriving at estimated genomic breeding value of any new born male or female and for selecting them based on estimated genomic breeding value without waiting for their own or progenies' production records. This way the time required for selection of bulls and bull mothers is considerably reduced.

The prediction equations developed in advanced dairy-producing nations are appropriate for their breeds mainly Holstein Friesian and Jersey. Neither the SNP genotyping chips developed for Holstein Friesian and Jersey breeds nor the prediction equations developed based on reference populations of other countries would be useful for many indigenous breeds in Asian countries. For introducing genomic selection procedures in the indigenous breeds, therefore, two tasks will be needed: One to develop cost effective SNP genotyping chips specifically for these breeds, and Second, to develop prediction equations based on phenotypic records within the country. As no progeny testing programmes are in place for many indigenous breeds, there are no phenotypic records in the form of breeding value of proven bulls in many Asian countries. In the absence of breeding values of bulls with high accuracy, appropriate models and methodologies will need to be developed based on primarily using phenotypic and genotypic records of females for arriving at suitable prediction equations. Recent studies have indicated that the reliability of predicted breeding values of male calves could be raised even when prediction equations are developed based on a mix of a small number of progeny tested bulls and a large number of recorded females (Pryce et. al. 2012).

5.6 ET and IVF

ET and IVF have primarily been used for production of male calves to be used for semen production. A very large number of bulls put to test by many breeding companies in North America and Europe under progeny testing programmes had been produced through ET/IVF before they changed over to genomics. Under genomics selection procedures, ET, OPU and IVF technologies have become more important, as it is advisable to produce more male calves from a very best selected sire and a very best selected dam and choose one having the highest genomic breeding value. All male calves of the same parent do not have the same genomic breeding values. Besides, to increase the intensity of selection on the male side hundreds of male calves are produced from which a few very best on genomic breeding values are selected for the production of semen doses. With increased efficiency of ET and IVF, they have also been becoming competitive to produce even replacement heifers and certainly they are chosen technologies when it comes to export/import of embryos. In medium and long terms, for many Asian countries ET/IVF will become important tools for production of male calves for semen production and for production of elite heifers, more so if whole genomics selection procedures are introduced. It is therefore very important for the Asian countries that intend to introduce genomics procedures to focus on building both an infrastructure for ET and IVF as well as the capacity of people to use ET and IVF. The use of ET, OPU and IVF in buffaloes is limited and requires more rigorous R&D efforts to make them more efficient.

5.7 Sexed Semen

Sexed semen helps focus at milk production by producing only female calves and save resources on unwanted males (very relevant for those Asian countries where cattle cannot be slaughtered). It accelerates genetic progress by increasing selection intensity on dam-dam path. It also opens an opportunity for farmers to sell surplus heifers to other farmers. It can also help in increasing efficiency of progeny testing (PT) and embryo transfer and IVF programmes.

At present the only reliable sexed semen technology available is by Sexing Technology (ST), USA, which has IP (Intellectual Property) on Flow Cytometry

Bovine Sperm Sorting (FC-BSS). All semen stations across the world use ST-operated and owned FC-BSS. Current machine of ST can produce about 10-14 doses of sexed semen of each sex per hour or about 300 doses per day or 100 thousand doses per year. ST is not selling their machine; it provides sperm sorting services with very high cost per sexed semen dose. There are no alternative sexed semen technologies available at present.

Sexing of semen is very relevant for many Asian countries. Any efforts made in developing practical tools to sex semen will be of great relevance.

5.8 Bio-informatics

With the introduction of test day random regression procedures for estimation of breeding values simultaneously for multiple traits, the estimation procedures are becoming more complex. On the genomics side, handling of both the SNP data and the estimation of genomic breeding values is becoming more and more complex. Any country wanting to use whole genome selection methods for choosing young males for semen production has to invest in building both an infrastructure and the capacity of people to handle large data.

6.0 POTENTIAL AREAS OF INTERNATIONAL COOPERATION

6.1. Standard Operating Procedures

It is essential that Dairy Asia uses the expertise developed elsewhere when it is relevant to the Asian situation. Much of the world has better experience of developing a dairy industry and Dairy Asia must benefit as much as possible from such experiences in all aspects of development.

The most obvious aspect from the livestock perspective is that of **Recording.** There already exists a globally established basis for recording and Asia should take advantage of this by agreeing to adhere to the standards and definitions laid out by the International Committee for Animal Recording (ICAR). This organization is an International Non-Governmental Organisation (INGO) established some 65 years ago. It now has about 120 members from 60 countries including some Asian countries. ICAR regularly updates and publishes a document on "International Agreement of Recording Practices" covering all aspects of Identification, Recording, Milk Analysis, Genetic Evaluations, etc. (latest 2016, ICAR). It also publishes technical series and all proceedings of the workshops/seminars organized. It holds biennial meetings at different places. All publications of ICAR can be accessed at icar.org. ICAR also cooperates with many other organizations such as European Association of Animal Production (EAAP), International Dairy Federation (IDF), FAO, etc. Dairy Asia needs to consider how best to be involved in this organization with the possibility that all participants in Dairy Asia are required to be members of ICAR. A member organization is required to pay annual membership fees.

Membership of ICAR would provide all Dairy Asia members with an opportunity to operate to international standards including certification of various procedures that would assist in the further development of international trade.

6.2. Capacity Building

The dairy industry in Asia has a considerable range of abilities in the different aspects of such an industry. Few Asian countries possess considerable experience in breed improvement practices although many attempt to carry out such programmes. The capability has considerable variation within Asia and requires much attention if Dairy Asia is to make progress in the genetic capability of the various dairy populations.

It may also be pertinent to mention here that the knowledge base in population genetics has been decaying over the years both at the level of academic institutions and at the level of implementing agencies. It is apparent that genetic improvement programmes cannot be implemented successfully unless they are managed by people having sound knowledge in population genetics.

Training programmes either using the experience of the successful Asian countries or that of ICAR members should be established early on in the progression of Dairy Asia given the time scale for results. A study of those programmes of greater relevance to the Asian requirement should be undertaken prior to the establishment of a full programme of training workshops.

Given that such programmes are expensive a funding mechanism needs to be developed prior to the commencement of such a series. While donor agencies may be involved it would be a mistake to rely on such for a long term programme. Training workshops on specific aspects of the components of successful breeding schemes would be advisable but the participants need to be limited to those actively involved in that specific area within the members scheme i.e. participation should be limited to committed actors only.

Seminars/conferences should be used for the exchange of information both on specific aspects of dairy improvement schemes and on research required. Proceedings must be made available at an early date and to all Dairy Asia members.

Study tours are a useful method for the exchange of experiences but again need to be subject to limitations on those who can participate given past experience of the regular abuse of such tours. Such tours should also require full reports available to all Dairy Asia members

Funding

Such capacity building is expensive and while the aim should be for Dairy Asia members to cover the costs of their participants, this may not be possible especially in the early years of the project. Donor agencies should be approached to assist with support – probably by a joint request from the host country and FAORAP. In order to assist in coping with costs, wherever possible, such courses/seminars/conferences should be held alongside relevant outside meetings to allow participants and Dairy Asia members to benefit from the reduction in travel costs. Examples in Asia would be AAAP 2017 and WCGALP 2018 since both are held in Dairy Asia members countries.

It is important to accept that after the initial years, members will need to have developed a funding mechanism within Dairy Asia to assist with all capacity building.

6.3 Exchange of Genetic Material

Consideration of the global recommendations (possibly requirements) under Access and Benefit Sharing (ABS) arrangements will need to be taken into account – Dairy Asia can make recommendations but ABS is a national commitment by all countries that have ratified the relevant agreement.

It is recommended that any proposed exchange should, prior to any agreement, be required to include full details of the genetic material to be exchanged, the breed details and the environment/management in which the breed normally exists.

These need to be considered as two separate types – **Within Dairy Asia countries** and **Outside Dairy Asia countries.**

As for genetic exchanges, the essential requirements for any such exchange must be the agreement of the protocols and health requirements of each participant – reference to guidelines from ICAR and OIE should be the starting point for all such arrangements.

Given the plethora of programmes operating within the Dairy Asia countries, the potential for Within Dairy Asia Joint programmes should be regarded as a crucial component if Dairy Asia is to make significant genetic progress. Many countries have relatively small populations of dairy animals which mean that the potential for within country genetic progress is severely limited (some might argue impossible).

The most important factor is to identify the specific national schemes and to assess these in terms of cost effective and sustainable genetic progress. Dairy Asia should assist countries to evaluate their programme and to suggest future policies that would provide the most effective use of genetics in providing long-term, cost effective permanent dairy improvement.

6.4 Joint Programmes

China and Thailand have been implementing a progeny testing programme in HF, they may think about establishing an across country genetic evaluation system, which can benefit both the countries. Similarly, India, Pakistan and the Phillipines have been implementing a progeny testing programmee in Murrah/Nili Ravi buffaloes. They may think of setting up an across country genetic evaluation system in buffaloes.

The advantages of creating an inter-country common reference population for implementing genomic selection strategies have now been well documented. Excellent examples of cooperation in this regard are Eurogenomics – cooperation among six European countries: Germany, France, the Netherlands, Denmark, Spain and Poland – and a consortium of the US and Canada. One may think about having such a consortium for establishing a common reference population for implementing genomic selection procedures in Asia.

Any joint programme will require clear determination of the responsibilities of each party and legally binding agreements to support these. If the latter do not exist there needs to be clear guidelines with penalties for non-compliance given the importance of such cooperative programmes. Dairy Asia needs to establish relevant working groups to assist in these matters.

Joint Programmes with parties outside Dairy Asia will require similar agreements laying out responsibilities and ownership of the joint material or of that material provided to the Dairy Asia members by outside agencies.

6.5 Joint Ventures

Dairy Asia aims to provide the complete cover of all aspects of the dairy industry in Asia and, as such, enables the formation of joint ventures either between different components of the industry or between members in the same sector.

Dairy Asia can provide the platform but the arrangements for such ventures are solely the responsibility of the parties involved. Dairy Asia cannot become involved in any financial aspect of such ventures.

Dairy Asia can, with cooperation of its membership, provide an Advisory group to assist such joint venture proposals in designing the basic arrangement but is not responsible for any outcome thereof.

7.0. THE ROLE OF DAIRY ASIA

DAIRY ASIA is essentially an umbrella under which all aspects of the dairy industry in Asia can work together for more effective development.

In many ways, it can be considered as a Regional Focal Point (RFP) for the Asian Dairy Industry linking the National Focal Points of member countries.

It is important to realize that the RFP can only be of real value when all countries act in good time and share all information – both technical and political - regarding the many aspects of the industry.

DAIRY ASIA should provide the crucial link ensuring that all members are fully informed of all activities and news on a regular and frequent basis.

DAIRY ASIA should provide the forum by which members can discuss any aspect of the industry and should summarise the results of such to circulate to all members.

DAIRY ASIA should act as the link with other dairy organizations outside Asia for liaison where /when required and ensure that Asia is properly represented to the rest of the world in all relevant fora.

DAIRY ASIA can act as the centre for assistance in the development of project proposals and funding applications and the subsequent monitoring of such.

DAIRY ASIA can assist with administration for regional workshops/ training courses.

DAIRY ASIA is not and cannot be a funding agency unless the members determine subscription funds from the membership for such purposes.

DAIRY ASIA cannot operate without the full support and participation of ALL members.

8.0 CONCLUSIONS

1. The Asian dairy industry has developed considerably over the last 40 years and continues to do so particularly in view of the demand predictions for the next 35 years.

2. The future of the Asian dairy industry will depend on how efficiently the production of milk and its products is carried out compared to that of countries now exporting to the region.

3. The genetic strategies undertaken to date are highly variable and are likely to achieve very variable rates of genetic change which may, in some cases, seriously jeopardize the chances of success.

4. There is a clear need for evaluation of the different country strategies with a view to coping with climate change effects both on the environment and on feed availability.

5. The traditional methods of genetic change can still provide benefits but the introduction of genomic selection should add to these. To begin to exploit genomics there is an urgent need to obtain full phenotypic records of the main breeds to be used in the future and this is likely to include some indigenous breeds.

6. There is a clear need for the exchange of information and experiences between Asian countries in all aspects of the dairy industry but particularly in genetics and genomics and data management.

7. There is a need for a specialist Working Group to assist all countries in planning their future genetic strategies.

8. DAIRY ASIA is the regional forum by which the optimal success in adapting the necessary genetic strategies is likely to be achieved as long as all members actively participate in it and support it.

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Annex I

Questionnaire – collecting national data on genetic improvement programmes for dairy cattle and buffaloes.

1. **Population and productivity**:

   Please provide latest available population and productivity figures.

1.1 Overall Population and productivity:

Year[1]:

	Cattle	Buffaloes
Number of total animals[2]		
Number of milk animals[3]		
Average yield per day per animal in kgs.[4]		
Total annual milk production in tones[5]		

[1] Write the year for which data are provided in the table

[2] Total animals includes all female young calves, heifers, adult females, male young calves, growing male calves and adult males

[3] Number of milk animals means number of female animals in milk during the year

[4] Average yield per day per animal means average milk production per day of all animals in milk

[5] Total annual milk production means total milk produced by cattle/buffaloes in a year

1.2 Breeds:

Please list the local and exotic dairy breeds kept in the country:

Sr. No.	Cattle		Buffaloes	
	Local	Exotic	Local	Exotic

Add as many rows as required to complete the list of all breeds

1.3 Population and Productivity details:

Please provide population and productivity figures in terms of well-defined local breeds, non-descript and exotic/crossbreds, if available.

Year:

	Cattle	Buffaloes

	Local	Non-descript	Crossbreds/ Exotic	Local	Non-descript	Crossbreds / Exotic
No. of total animals						
No. of milk animals						
Avg. yield per day per animal in kgs.						
Total annual milk production in tones						

1.4 Population trends:

Please indicate population trends by ticking an appropriate cell in the table below:

	Cattle Breeds			Buffalo Breeds		
	Local	Non-descript	Crossbreds/ Exotic	Local	Non-descript	Crossbreds/ Exotic
Increasing						
Steady						
Declining						

2. Semen production and Artificial Insemination infrastructure:

2.1 Semen doses produced agency wise:

Year:

	Agency	No. of semen stations[6]	No. of frozen semen doses produced
1	Government		
2	Cooperatives/Breeders associations		
3	Non-governmental organisations		
3	National private companies		
4	International private companies		

5	Others		
	Total		

[6] Semen station means a place where frozen semen doses are produced

2.2 Semen doses produced species wise:

Year:

	Species	No. of doses produced
1	Cattle:	
1.1	Local breeds	
1.2	Exotic breeds	
1.3	Crossbreds	
2	Buffaloes:	
2.1	Local breeds	
2.2	Exotic breeds	
	Total	

2.3 Number of doses imported:

	Species	No. of doses imported
1	Cattle:	
1.1	Pure Exotic:	
1.1.1	Holstein Friesian	
1.1.2	Jersey	
1.1.3	Others	
1.2	Crossbreds	
2	Buffaloes	
	Total	

2.4 Infrastructure of artificial insemination

Year:

	Agency	No. of AI technicians	No. of AIs carried out		
			Cattle	Buffaloes	Total
1	Government				

2	Cooperatives/Breeders associations				
3	Non-governmental organisations				
3	National private companies				
4	International private companies				
5	Others				
	Total				
	Percentage of breedable females inseminated				

3. Genetic improvement programmes:

3.1 Implementation of various activities:

List the breeds in a suitable cell for which the activities mentioned in the table are carried out.

Year:

	Activity	Cattle			Buffaloes
		Local	Crossbreds	Exotic	
1	Animal Identification[7]				
2	Performance Recording[8]				
3	Pedigree Recording[9]				
4	Genetic Evaluation classical – progeny testing[10]				
5	Genetic evaluation incorporating genomic information[11]				

[7] Animals are identified uniquely by applying an ear tag or any other identification device

[8] Animals are individually recorded for economically important traits viz. milk yield, growth, reproduction, types, logitivity, etc.

[9] Pedigree records of individual animals are maintained

[10] A classical progeny testing programme is carried out for estimating breeding values based on performance and pedigree records

[11] Breeding values are estimated incorporating genomic data

3.2 Involvement of different institutions

Please indicate the level of involvement of different institutions by putting "N" for no involvement, "L" for low involvement, "M" medium involvement and "H" for high involvement in an appropriate cell in the table below:

	Activity	Govern-ment	Coope-ratives	NGOs	Private local	Private Interna-tional	Others
1	Animal Identification						
2	Performance Recording						
3	Pedigree Recording						
4	Genetic Evaluation classical – progeny testing						
5	Genetic evaluation incorporating genomic information						

3.3. **Funding of Genetic Improvement Programmes**:

Please indicate how different schemes are funded by ticking an appropriate cell in the table below:

	Activity	Govern-ment	Coope-ratives	NGOs	World Bank Loan	ADB Loan	Others
1	Animal Identification						
2	Performance Recording						
3	Pedigree Recording						
4	Genetic Evaluation classical – progeny testing						
5	Genetic evaluation						

	incorporating genomic information						

4 **Data collection and dissemination of information**

Please provide how data are collected and information is disseminated by ticking an appropriate cell in the table below:

	Manual	Computerised	
		Decentralised[12]	Centralised [13]
Semen production			
Artificial insemination			
Genetic improvement programmes			

[12] Managed independently by each institution

[13] Several institutions together maintain a common database

5. Training and research facilities

Indicate the state of training and research in the table below indicating "N" for none, "L" for low, "M" for medium and "G" for good.

		Training	Research
1	Semen production		
2	Artificial insemination		
3	Genetic improvement		
4	Information Systems		

6. Further information:

Please provide information on each of the area mentioned in the table below:

	Description
Constraints faced in bringing about a steady genetic progress in the country	

Key priority areas for achieving genetic progress in the country	
Key interventions required	
Policies and regulatory frameworks required	
Expectations from Dairy Asia Platform	

Date:
Name of Responder:
Country:
Signature:

Annex II

Decision matrix for selecting a breeding strategy under different conditions

There could be many levels of climate; for simplicity one could put them into two groups: (i) harsh environment – poor vegetation, low rainfall and high temperature-humidity index, and (ii) favourable environment – good vegetation, medium to good rainfall, moderate temperature-humidity index. Economic conditions of farmers could also vary very widely; for simplicity these conditions could be grouped into two groups: (i) poor-resource farmers, and (ii) good-resource farmers. Farmers may have pure local breed of animals or exotic breeds or their crosses. The table below describes appropriate breeding strategy for different combinations of climatic conditions, category of farmers and type of animals.

Spe-cies	**Breed**	**Harsh Environment**		**Favourable Environment**	
		Poor-resource Farmers	**Good-resource farmers**	**Poor-resource Farmers**	**Good-resource farmers**
Cattle	**Local Non-descript**	Upgrade with a local breed	Upgrade with a local breed or CB<=50% Exotic	Upgrade with a local breed or CB=50% Exotic	CB=50% Exotic
	Local well-defined breed[1]	Selective breeding within breed	Selective breeding within breed	Selective breeding within breed	Selective breeding within breed
	Crossbreds[2]	CB<50% Exotic	CB=50% Exotic	CB=50% Exotic	CB>50% Exotic
	Exotic[3]	Not advis-able	Not advisable	Not advisable	Selective breeding

Buffa-lo	**Local Non-descript[4]**	Upgrade with Riverine breed	Upgrade with Riverine breed	Upgrade with Riverine breed	Upgrade with Riverine breed
	Riverine breed	Selective breeding	Selective breeding	Selective breeding	Selective breeding
	Crossbreds[5]	Upgrade with a Riverine breed	Upgrade with a Riverine breed	Upgrade with a Riverine breed	Upgrade with a Riverine breed
	Swamp breed	Selective breeding	Selective breeding	SB or CB with a Riverine breed	SB or CB with a Riverine breed

[1] *Bos Indicus* breed; [2] Crosses of *bos Indicus* and bos Taurus; [3] Bos Taurus breeds – Holstein Friesian, Jersey, etc. ; [4] non-descript Riverine breed; [5] crosses of Riverine and Swamp; SB Selective Breeding; CB crossbreeding

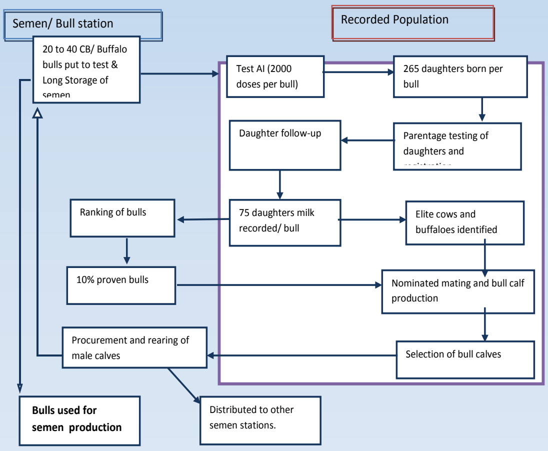
A few points that need to be highlighted are: (i) All well-defined breeds in their native tract and in other areas should be developed further through selective breeding; crossbreeding of well-defined breeds should be discouraged in all areas; (ii) Poor-resource farmers in a harsh environment should be advised to upgrade their local non-descript cows with a bos Taurus breed and their local non-descript riverine buffaloes with a riverine breed; crossbreeding of cows with an exotic breed should be discouraged; if some such farmers like to keep crossbred cows, the exotic inheritance should be less than 50% (CB<50); (iii) Good-resource farmers in a harsh environment should be advised to upgrade their local non-descript cows with a bos Taurus breed and local non-descript buffaloes with a riverine breed; if some such farmers like to keep crossbred cows, the exotic inheritance should not be more than 50% (CB=50); (iv) Good-resource farmers in a comfortable environment may keep higher-grade crossbreds (CB>50) and higher-grade Swamp-Riverine crossbred buffaloes.

Source: Dr. K. R. Trivedi

Annex III

Progeny testing programmes implemented by NDDB under its National Dairy Plan (NDP)

NDDB, under its NDP, has initiated 13 large field-based progeny testing programmes - one for pure Holstein Friesian, four for Holstein Friesian crossbreds, two for Jersey crossbreds, four for Murrah buffaloes and two for Mehsana buffaloes. A schematic presentation of various activities that are undertaken under each programme is given in the Figure and briefly described below:



1) A minimum of 20 bulls of a breed are put to test in first year and raised to 40 within five years.
2) A minimum of 2000 test doses per bull are distributed in identified villages and about 3000 doses per bull are stored till progeny test results of the bulls put to test are available.
3) All female animals that are inseminated with test doses are identified with ear tags.
4) All events of artificial insemination, pregnancy diagnosis and calving of dams are recorded through INAPH (Information Network for Animal Productivity and Health) application.
5) All daughters born are identified with ear tags and followed up for growth.
6) When daughters reach serviceable age, they are inseminated with semen from test bulls of future batches and later followed up for pregnancy and calving, all data are recorded through INAPH.
7) Milk production and milk components like fat, protein, lactose, etc. of all the daughters that calve are recorded once a month for a complete lactation.
8) Breeding values of bulls put under test and the milk recorded cows are estimated using a random regression model using test day records.
9) Top 10% of recorded cows/ buffaloes are declared as elite animals.
10) The stored semen doses of top 5-10 progeny tested bulls are used for nominated mating of elite cows/buffaloes to produce the next generation of superior bull calves.

11) The bull calves produced through nominated mating are procured after a preliminary selection and subject to meeting the standard protocols of parentage, health and fitness.
12) Procured bull calves are first kept at a quarantine station and tested for TB, JD and brucellosis and later those tested negative are shifted to a rearing station where they are tested again for TB, JD and brucellosis and reared up to maturity.
13) Mature bulls are supplied to semen stations.

Till September, 2016, the 13 progeny testing programmes together had completed testing of 562 bulls, 378 bulls were under test, carried out 2.24 million test inseminations, registered 0.21million daughters, completed milk recording of 9,500 daughters, completed milk recording of 62 thousands dams, and distributed about 600 high genetic merit bulls to different semen stations. The traits recorded under each programme include: test-day yield, test day fat, protein, SNF, and lactose percentages, 305-day lactation yield, 305-day fat yield, 305-day protein yield, age at first calving, service period, no. of inseminations per conception, inter calving period and calving ease. Typing of animals for internationally standardized 16 linear type traits are in progress. The five programmes – KMF for HF, SAG for HF CB and Murrah, Mehsana Union for Mehsana buffalo and Banas Union for Mehsana buffaloes – that had more than 30 daughter records per bull were included in estimating breeding values during the last run carried out during September 2016. A random regression test day model was used for estimating breeding values. The breeding values of the bulls, having reliability more than 70% in case of cattle and more than 60% in case of buffaloes, have been published.

Source: www.NDDB.coop

Annex IV

NDDB's Information Network for Animal Productivity and Health (INAPH)

The National Dairy Development Board of India has developed an integrated IT System referred to as "Information Network for Animal Productivity and Health (INAPH). INAPH covers all areas of productivity enhancement including animal registration and identification, traceability, artificial insemination, milk recording, genetic evaluation, ration balancing, health (treatment, diagnosis, testing, vaccination and outbreaks), and advisory services. The idea is to bring together all service providing organizations in the country and develop an industry level database on productivity of animals.

INAPH is based on field force automation using mobile technology (GSM or CDMA). The field force is provided with handheld devices (Smartphones/Netbooks/laptops) to record activities in real time with proper validation and to generate information for monitoring and control of their daily activities at the village level. Field level workers synchronize their data with the INAPH central server at Anand in the state of Gujarat using GPRS/CDMA services. The Web-based version of the network is available on the desktop/laptop for entering data and generating the required information. The desktop version is developed using .net framework. A DBMS Microsoft SQL server is set up at Anand to host data. A separate web server is maintained to host all web-based applications. The Microsoft ASP .net framework is used in developing the applications.

Different components of the network that are operated independently include: (i) Admin Application; (ii) PDA Application; (iii) Desktop Main application; (iv) Laboratory Application; (v) Analytical Reporting Application; (vi) SMS Application; (vii) INAPH MIS Tools, and (viii) Database Synchronization Middleware. The INAPH application produces a variety of reports for each service. The various reports have been developed considering the requirement of different users; the reports generated by INAPH could be grouped into seven classes: Operational Reports, Performance Review Reports, Analytical Reports, Graphs, Alerts, SMS Messages, and Data Extraction Tools. The system also has facility to send SMS messages to farmers on their cell phones to alert them on what is due on animal(s) they have (For details visit: www.NDDB.coop)

As on 1st September, 2016, INAPH had records of 6.48 million registered animals, 3.54 million registered farmers, 5.31 million AIs, 1.07 million calving, and 1.65 million test day records. These records were spread over about 74,000 villages and there were about 34,400 users of INAPH.

Source: Dr. K R Trivedi