Review Paper

Buffalo Husbandry for Sustainable Development of Small Farmers in the Developing Countries

ABSTRACT

Aim of this paper is to tap the potential of buffalo husbandry for providing sustainable livelihood small farmers in the developing countries. The world population of 200 million buffaloes has been distributed over 40 countries, but 97 percent population is confined to Asia and India with 109 million buffaloes hosting 57 percent of the total population. These include swamp buffaloes, which are used for meat and draught purpose and river buffaloes which are mainly maintained for milk production. Buffalo is hardier than cattle because of its ability to digest coarse fibre but susceptible to high temperature. India is the highest buffalo milk producer in the world with over 20 breeds of river buffaloes. Among these, Murrah and Jaffarabadi are popular because of high milk yield, although several other breeds have unique economic traits. Introduction of breeding services using frozen semen in late 1970s enabled small farmers owning nondescript buffaloes, to produce superior progeny and enhance the productivity of buffaloes. With genetic improvement, health care, proper feeding and establishment of marketing network, it should be possible to enhance the milk and meat production of buffaloes in the future. There is also scope to promote buffalo husbandry for milk

Keywords: Buffalo milk, Water buffalo, Asian River buffalo, Buffalo husbandry

1. BACKGROUND

Asian water buffalo, which is commonly known as buffalo in India, has been an important source of milk in the Indian sub-continent since ages, but neglected in other parts of the world. Although buffalo contributed only 12 per cent of the world milk production, it was the main source of milk in India and Pakistan. It has been reported that Asian water buffalo - *Bubalus bubalis*, was domesticated independently in India about 5000 years ago and in China even before 4000 years, from a wild stock resembling *Bubalus arnee*. The domesticated buffalo was introduced across southern mainland Asia, Southeast Asia and the Middle East during the next few hundred years. After a long gap, about two thousand years ago, it was introduced in north-eastern Africa and southern Europe. It was only in the twentieth century that buffalo was introduced in South America (CABI, 2018).

Buffaloes have been widely mentioned even in ancient Indian mythological scripts, along with cows. However, while the cow was considered as the holiest animal in India, buffalo was mentioned as the vehicle of Lord Yama, the God responsible for carrying the soul of dead persons from earth to heaven or hell. Another reason for neglect of buffaloes was high fat

content in milk. Hence, without glorification, buffaloes were maintained for milk, dung and bullock power by farmers in India. As buffaloes were hardier than cows, particularly their ability to survive on fibrous crop residues, small and poor farmers preferred to maintain buffaloes. With better awareness about the harmful effects of fat on human health, the Indian ancient herbal medical system discouraged the consumption of buffalo milk and used cow milk and butter oil for treating several ailments (Rao, 2017). Inspite of such negative stigma about buffalo milk, the demand for buffalo milk has been growing in India because of its taste, particularly for preparing tea, curd and certain kinds of Indian sweets. During recent years, with better awareness about the quality of milk and available technologies to reduce the fat content without changing other qualities, buffalo milk is regaining its popularity not only in India but also in many other countries, in different continents. With better awareness and application of modern science and technologies, the productivity of buffalo can be enhanced significantly, while increasing the popularity of its milk. With high protein and calcium, low cholesterol and reducing the fat content before consumption, the economy of buffaloes can surpass cows in all respects.

2. CLASSIFICATION OF BUFFALO SPECIES

Water buffalo, belongs to the species *Bubalus bubalis* under the Class Mammalia, Subclass – Ungulate, Order – Artiodactyla, Suborder – Ruminantium, Family – Bovidae Subfamily – Bovinae and Tribe – Bovinae – Genus - Bubalus (CABI, 2018). This tribe comprises of the following three groups:

2.1 Tribe Bovinae: Three groups

1. **Bovina (cattle)**
2. **Bubaline (Asian buffalo): 5 Species –**
- *Bubalus depressions or anoa*: In Indonesia
- Bubalus carabanesis : Swamp buffalo in the Philippines
- *Bubalus mindorensis*: Swamp buffalo in the Philippines
- *Bubalus arnee:* Indian wild buffalo
- Bubalus bubalis: Indian Water / River Buffalo

3. **Syncerina**: *Syncerus caffer* (African buffalo)

2.1.1 Types of Asian Buffaloes

Among Asian buffaloes, there are the following two subspecies (Buffalopedia,1999):

1. Swamp type (48 chromosomes)
2. River type (50 chromosomes)

Buffalo is known as 'Water buffalo' because of its natural instinct to wallow in water ponds and muddy pools. Buffalo is well adapted to humid tropical climates, but highly susceptible to thermal stress, due to low density of sweat glands on skin. Therefore, their direct exposure to sun rays, can lead to depressed food intake, disturbances in water metabolism, protein, energy and mineral balances, hormonal secretions and enzymatic reactions. Buffaloes thrive well in moderate rainfall areas and need plenty of water for wallowing.

Swamp type Buffaloes: These are lean and stocky animals with marshy land habitats and are found in China, Thailand, the Philippines, Indonesia, Vietnam, Myanmar, Laos, Sri Lanka, Kampuchea, Malaysia and North Eastern states of India. They are slate grey in colour, with droopy neck and massive backswept horns and slightly low in weight compared to river type buffaloes, with the adult male weighing 325 - 450 kg. The females yield upto 600 kg milk per lactation, which is significantly low compared to river buffaloes. These animals are used as draught animals, particularly for rice cultivation and have good potential for meat production. The progeny produced from crossings between river and swamp buffaloes in Thailand, Philippines, Vietnam, and China are powerful work animals, with good quality meat and higher milk production (Hays, 2008).

River Buffaloes: This buffalo species was domesticated in India, where buffalo was the main milk producing species till last few decades. These buffaloes, also known as Asian water buffaloes, are found in India, Pakistan, Bulgaria, Hungary, Turkey, Italy, Egypt, Brazil and Caucasia, and are primarily for milk production and good for meat and draught purposes as well. These buffaloes are large in size, with the adult male weighing 450 - 1000 kg, black or dark grey in colour, with tightly coiled or drooping straight horns. They prefer to wallow in clean water and rivers. Buffalo milk with 7 to 8 per cent fat and 3.9 per cent to 4.5 per cent protein, is richer **in** quality than cow milk.

3. BUFFALOES IN ASIA

Buffalo population is concentrated in Asia, under different management systems, for specific uses. In China, Swamp type buffalo breeds are found only in the lowlands. River type breeds live only in the mountains. Thailand has the second largest number of Swamp buffaloes in the world. However, this buffalo population has drastically declined from 4.7 million in 1990 to 1.9 million in 1998. In Indonesia and Malaysia, both Swamp and River buffaloes are present. Water buffalo is known by different names such as Dombay, Camiz or Camis in Malaysia and as Komus in Turkey. Swamp buffalo is called *carabao* in the Philippines, where it is regarded as the national animal. These are being crossed with Bulgarian Murrah to develop buffaloes, which are good for meat, milk and draught. In Vietnam, there are only Swamp buffaloes, used for bullock power and meat. In Sri Lanka, Swamp buffaloes are crossed with Murrah for milk and draught purposes. In Bangladesh, Swamp buffaloes are crossbred with River buffaloes such as Murrah and Nili-Ravi for milk production. In Pakistan, only river buffaloes are found, mostly for milk production. Main milk breeds of Pakistan are Nili-Ravi, with an average milk yield of 2070 kg/lactation and Kundhi breed with an average milk yield of 1825 kg/lactation (Borghese and Mazzi, 2005).

4. ECONOMIC FEATURES OF BUFFALOES

Buffaloes share 12 per cent of the world's milk production and India and Pakistan together produce 90 per cent of the world's buffalo milk. Dairy buffalo industry is flourishing in Italy due to popularity of buffalo mozzarella cheese in Europe. In Brazil and Argentina, buffaloes are reared for milk and meat production. High-yielding Murrah breed of buffalo is as good as Holstein Friesian cow among buffaloes. Buffalo milk contains 100 per cent more butter fat compared to cow milk, while buffalo meat has high protein, low fat and cholesterol compared to cattle meat. Buffalo calf can achieve weight gain of 800 gm /day without any supplementary feed, resulting in low cost of production.

Buffaloes have high feed conversion ability, due to slow, efficacious chewing motion with more developed muscle fibres, digastric muscle and masseter muscle. They have slower ruminal movements, smaller rate of outflow from rumen and higher bacteria population in rumen fluid, leading to complete digestion. With ability for 5 per cent higher digestibility of crude fibre and 4-5 per cent higher efficiency to utilise metabolic energy for milk production, buffaloes can convert poor-quality roughage into milk and meat. Buffaloes do not have physiological need for concentrate feed to maintain body tissues. As buffaloes release unwanted fat in the milk, storing minimum in body tissues, feeding of concentrates will result in high fat content in milk (Dhanda, 2006).

Contrary to common belief, buffalo milk is more notorious and healthy, except for high butter fat, as presented in Table 1. Buffalo milk is rich in protein, lactose, energy and calcium and low in cholesterol, apart from 3 per cent high fat.

Table 1. Comparative nutritive value of milk

Traits	Cow	Buffalo
Total solids, %	13.10	16.30
Fat, %	4.30	7.90

Protein, %	3.60	4.20
Lactose, %	4.80	5.00
Tocopherol, mg/g	0.31	0.33
Cholesterol, mg/g	3.14	0.65
Calcium, mg/100 g	165	264
Phosphorus, mg/100 g	213	268
Magnesium, mg/100 g	23.0	30.0
Potassium, mg/100 mg	185.0	107.0
Sodium, mg/100 g	73	65
Vitamin A (incl. Carotene) IU.	30.30	33.00
Vitamin C, mg/100 g	1.90	6.70

Source: Dhanda (2006)

5. SPECIAL FEATURES OF BUFFALOES

Buffaloes being docile, they are easier to manage and milk. Buffaloes with cool temperament, have higher intake of concentrate, shorter let-down time, longer milking time, higher daily milk yield and higher fat content in milk. Providing cool drinking water and shower in the afternoon, will improve feeding and milk yield by 20 – 25 per cent. However, there a few breeds of buffaloes, which can withstand heat up to 47^0C, without drop in milk production.

Buffaloes eat well after morning and evening milking and eat moderately around noon and midnight. Their rumination is intense after each peak of eating. It is highest during early morning and late evening, and least around noon. Buffaloes consume 3 times more water in cooler seasons and 4 times more during warmer seasons/day. Their peak sleeping times are around 11 pm and 3 am. Table 2 indicates the time spent by buffaloes on various activities during the day (de la Cruz-Cruz *et al*, 2014).

Table 2. Time spent on various activities

Activities During the Day (24 Hours)	Percent time Spent
Grazing	58.6
Rumination	28.2
Lying down / Resting	26.5
Wallowing	12.9
Standing	1.4

Source: Dhanda (2006)

6. GROWTH HABIT AND MATURITY IN BUFFALOES

Generally, female buffalo calves attain puberty at 36 to 42 months of age, although with good feeding and healthcare, heifers can gain 300 to 350 kg weight in 24 months. It is ideal to breed the heifers after weight gain of 325 kg. Bull calves also reach sexual maturity in 2 to 3 years. Ideal weight for Murrah buffalo at first calving is 450 to 500 kg (Dhanda, 2006). The age at first calving is around 40 to 60 months. The age at first calving can be easily reduced by balanced feeding from a young age. In Italy, the age at first calving is 28 to 32 months.

Most reliable signs of oestrus are - frequent urination, restlessness, difficulty in letting milk and slight decrease in milk yield during heat. Some buffaloes show oestrus only at night time. The length of oestrus cycle in buffaloes is 21 days, which may vary from 21 to 29 days, depending on the breed. The time of ovulation is 10 to 14 hours after end of oestrus and the duration of heat is 12 to 24 hours. The period of maximum fertility is 8 hours after oestrus. The gestation period of buffaloes is 310 days. The period of involution of uterus is 25 to 35 days. The lactation length is around 252 to 270 days. The calving interval in general is 15 to 18 months. Long calving interval is a common problem, which is due to silent heat and irregularities in reproductive hormones. The dry period varies from 60 to 200 days. Healthy buffaloes complete 9 to 10 lactations during their lifetime.

7. REPRODUCTIVE INEFFICIENCY IN BUFFALOES

Reproductive inefficiency is a major problem in buffaloes, which includes delayed puberty and low fertility. These are the reasons for higher age at first calving and longer calving intervals. While the major reason for higher age at puberty can be attributed to poor feeding, lack of health care, particularly control of ecto and endo-parasites, the reasons for low rate of fertility are as below (Dhanda, 2006).

Factors affecting Fertility: Buffaloes have several problems which affect their reproductive efficiency and some of the major problems are presented below.

- Fewer primordial cells in the ovary compared to cattle
- High rate of atresia reduce the number of normal Graaffian follicles in buffalo ovaries to reduce fertility
- Short duration oestrus, which are often undetected
- Lack of overt sign of heat (silent heat/sub-oestrus)
- Long post-partum anoestrus (absence of oestrus cycle), leading to infertility
- Variable time of ovulation and breeding seasonality
- Problem of uterine prolapse and retention of placenta, leading to uterine infections and endo-metritis, causing repeat breeding
- Under-feeding, deficiency in protein, minerals and vitamins
- Increase in milk production may lead to decline in fertility

Intolerance to Heat: Buffaloes are more sensitive than cattle to direct solar radiation and high ambient temperatures, which can affect their feed intake, growth, milk production and also fertility. The reasons for their sensitivity to heat are as below (Borghese and Mazzi, 2005):

- Dark body colour absorbs heat well when exposed to sunlight. Buffaloes have fewer sweat glands per unit area of skin, resulting in reduction in sweating.
- Thick epidermal layer of skin of buffaloes protects against heat loss. Hence, they are susceptible to extreme heat and cold and the conception rate is higher during cooler period.
- Heat stress will affect feed intake, milk production and reproductive efficiency. Hence, wallowing (immersing in water) is the practice to overcome heat stress. Buffaloes having showers and wallowing facilities have increased conception rate. Buffalo bull is most fertile in spring, with highest semen quantity, sperm count and vitality.

- Generally, 80 per cent buffaloes in India were calving during June - December, causing a decline in milk production from March to June. Thus, buffaloes were considered to be seasonal breeders, but it has been now realised that they can be bred year round with good management.

8. WORLD BUFFALO POPULATION AND MILK PRODUCTION

During 2013, world buffalo population was 199.78 million, as compared to cattle population of 1494.35 million, as presented in Table 3. Between the years 2000 and 2013, buffalo population had increased by 21.7 per cent, as compared to 14.7 per cent increase in cattle in 13 years. Among these buffaloes, 97 per cent were in Asia and the remaining 3 per cent were spread over South America, Europe, Middle East and Africa. Within Asia, 56.7 per cent world buffalo population was located in India, followed by 15.65 per cent in Pakistan and 12.56 per cent in China (Table 4). With regard to buffalo milk production in the world, out of 102 million tons produced during 2013-14, 99.22 million tons were produced in Asia and India contributed 70 million tons. During the same year, buffaloes contributed 3.72 million tons of meat, of which 89 per cent was produced in Asia and 43 per cent in India (Cruz, 2007).

Table 5 presents the population of buffaloes in Asian countries (Cruz, 2007). The annual population growth of buffaloes in the world has been at 0.8 per cent (between 1991 and 2002), while in Pakistan it was 2.8 per cent. The other countries having higher population growth were Philippines (2.2 per cent), Myanmar (2.1 per cent), Nepal (1.9 per cent), Iran (1.9 per cent) and India (1.2 per cent). Largest buffalo population in South America was in Brazil (3.0 mil.), followed by Colombia (0.3 mil.), Venezuela (0.15 mil.), Argentina (50,000) and Cuba (30,000), as presented in Table 6. There was a significant increase in the number of buffaloes from 30,000 to 0.3 million in Colombia during the last 10 -15 years, mostly for meat production, with support from the Government. The buffalo owners have established their Association to facilitate their member through information, vaccination and other support. There are many farms with 600 to 1000 buffaloes, maintained on extensive feeding system on private pastures. (Personal communication, 2018). Other countries having significant buffalo population were Egypt (3.717 mil.), Iran (0.4 mil.), Azerbaijan (0.29 mil.), Italy (0.265 mil.), Turkey (0.11 mil.), Romania (0.1 mil.) and Iraq (0.098 mil.), as presented in Table 7. India leads in buffalo milk production, followed by Pakistan, China, Egypt and Nepal (Table 8).

Table 3. World livestock population

Livestock Species	2000 (Million)	2013 (Million)	Change (per cent)
Cattle	1,302.90	1,494.35	14.7
Buffaloes	164.11	199.78	21.7
Sheep	1059.08	1172.83	10.7
Goats	751.63	1005.60	33.8
Pigs	856.24	977.02	14.1

Source: Cruz (2007)

Country	1997	2002	2008	Per cent of total	Annual Growth in 10 years (%)
India	89.91	95.10	105.10	56.7	1.53

Pakistan	20.83	24.00	29.00	15.65	3.56
China	21.73	22.25	23.27	12.56	0.64
Asia	154.91	161.50	179.75	97.01	1.45
Rest of World	4.28	5.62	5.54	2.99	2.67
World	159.19	167.13	185.29	100	1.49

Table 4. World buffalo population

Source: Cruz (2007)

Table 5. Buffalo population: ranking of countries in Asia

Rank	Countries	1991	2002	Growth Rate %
1	India	84.206	95.100	1.2
2	Pakistan	18.273	24.000	2.8
3	China	22.024	22.249	0.1
4	Thailand	4.728	1.800	-12.1
5	Indonesia	3.342	2.300	-3.9
6	Nepal	3.058	3.701	1.9
7	Vietnam	2.887	2.815	-0.4
8	Philippines	2.577	3.122	2.2
9	Myanmar	2.101	2.552	2.1
10	Lao PDR	1.130	1.060	-1.3
11	Sri Lanka	0.896	0.661	-2.5
12	Bangladesh	0.832	0.830	-0.5
13	Cambodia	0.804	0.626	-2.9
14	Iran	0.440	0.524	1.9
15	Malaysia	0.194	0.154	-2.0
	Asia & Pacific	147.504	161.504	0.9
	Rest of World	5.600	5.623	0.2
	World	153.104	167.126	0.8

Source: Cruz (2007)

Table 6. Buffalo population in America

Sr. No.	Country	Population
1	Brazil	3,000,000
2	Colombia	300,000*
3	Venezuela	150,000
4	Argentina	50,000
5	Cuba	30,000
6	Peru	25,000
7	Paraguay	10,000
8	Trinidad and Tobago	10,000
9	Ecuador	5,000
10	Bolivia	5,000
11	Other Countries: Belize, USA, Costa Rica, Guatemala, Mexico, Panama, Guyana	30,000
America Total		**3,615,000**

Source: Borghese (2005)

* Information based on the personal communication with Association of Buffaloes in Columbia in November 2018.

Table 7. Buffalo population in other countries

Countries	Total Buffaloes	Adult Female	Milk Yield (Kg/Lactation)	Lactation Days
Egypt	3,717,000	1,487,000	1,600	312
Iran	400,000	208,200	1,600	220
Azerbaijan	290,000	150,000	1,000	266

Italy	265,000	133,000	2,175	270
Turkey	110,000	58,806	1,247	230
Romania	100,000	42,300	1,200	270
Iraq	98,000	40,000	1,320	270
Bulgaria	9,200	5,880	1,870	278
Syria	4.500	1800	1,191	254
Greece	1,000	500	1,020	240
Albania	100	70	400	180

Source: Borghese (2005)

Table 8. Ranking of countries producing buffalo milk (2013-14)

Rank	Country	Milk Production (Million Tons)
1	India	70.000
2	Pakistan	24.370
3	China	3.050
4	Egypt	2.614
5	Nepal	1.188
6	Myanmar	0.309
7	Italy	0.195
8	Sri Lanka	0.065
9	Iran	0.065
10	Turkey	0.052
Total World		**101.908**

Source: Anonymous (2017)

9. BUFFALO DEVELOPMENT IN INDIA

In 2012, India had a buffalo population of 108.7 million, as compared to cow population of 190.9 million (184 per cent of buffalo population). The buffalo population in the past 5 years between 2007 and 2012 increased by 3.19 per cent while population of cattle decreased by 4.1 per cent during the same period. There has been a steady growth in buffalo population, during the last 60 years. The population of adult female buffaloes which was 21 million in 1951, increased to 56.6 million in 2012 (Table 9).

Till mid 70's, there was no major focus on improving the productivity of buffaloes, except in selected regions, which are the home tracts of important buffalo breeds. The State Animal Husbandry Departments and the Cooperative Dairy Federations, introduced AI services using liquid semen across the country, which was followed by preventive vaccination against

major diseases, providing veterinary health care, distribution of good quality fodder seeds and cattle feed and setting up of village level dairy cooperatives to organise collection of surplus milk for processing and marketing. Thus, no doubt, these initiatives helped to conserve the precious buffalo breeds and to increase the milk production in the traditional buffalo tracts. However there was no major impact in other regions as most of the farmers owned low yielding nondescript buffaloes and the conception rate using liquid semen was low. In the absence of efficient breeding services through artificial insemination, most of these buffaloes were naturally served by nondescript bulls, when they went for grazing on community lands. Low productivity led to neglect of these animals and the return from these animals was also very low.

Table 9. Contribution of buffaloes to milk production in India

Year	Total Bovines	Adult Female Cattle	Adult Female Buffalo	% of Buffalo to Total Milch Animals
1951	198.7	54.4	21.0	27.85
1961	226.8	51.0	24.3	32.27
1972	235.7	53.4	28.6	34.88
1982	262.2	59.2	32.5	35.44
1992	288.8	64.4	43.8	40.48
2003	283.1	64.5	51.0	44.16
2012	299.6	76.7	56.6	42.46

Source: Anonymous (2014)

In late 70's, frozen semen was introduced for breeding buffaloes and paravets were trained to provide breeding services at the doorsteps of buffalo owners, at an appropriate stage of heat. This was the beginning of buffalo development where small farmers owning poor quality nondescript buffaloes were able to produce superior progeny without heavy investment, while reducing unproductive animals. This was followed by good extension services to increase milk production, without increasing the herd size. Remunerative price for buffalo milk, based on the fat content, further attracted farmers across the country to maintain buffaloes, as a reliable source of income for sustainable livelihood (Hegde, 2018).

Table 10 presents the increase in milk production in India from 2000 to 2016 and the contribution of buffaloes to boost the production. It may be observed that inspite of significant growth in buffalo milk production, the share of buffalo was gradually reducing, because of massive development efforts to improve the progeny of nondescript cattle, which represented

almost 80 per cent of the total cattle population. Crossbreeding of cattle was another major success which enabled India to attain first rank in milk production in the world. The contribution of different categories of milch animals to National milk production is presented in Table 11.

Table 10. Milk production in India: contribution by buffalo

Years	Cow Milk Million tons	Buffalo Milk Million tons	Goat Milk Million tons	Total Milk Million tons	Share of Buffalo %
2000-01	32.957	43.428	3.266	79.651	54.52
2005-06	39.759	52.070	3.790	95.619	54.46
2010-11	54.903	62.350	4.594	121.847	51.17
2015-16	73.646	76.459	5.378	155.482	49.18

Source: Govt. of India (2017)

Table 11. Specieswise contribution to total milk production in India 2015–16

Sr. No.	Species	Percentage of Total Milk Production	Av. Milk Yield Kg/day
1	Buffalo indigenous	35	5.76
2	Buffalo non-descript	14	3.80
3	Cow indigenous	11	3.41
4	Cow non-descript	9	2.16
5	Cow cross-bred	26	7.33
6	Cow exotic	1	11.21
7	Goat	3	0.45

Source: Govt. of India (2017)

10. DISTRIBUTION OF BUFFALOES IN INDIA

Out of 109 million buffaloes, Uttar Pradesh has the largest population of 30.6 million buffaloes, followed by Rajasthan (13.0 mil.), Andhra Pradesh (10.6 mil.), Gujarat (10.4 mil.), Madhya Pradesh (8.2 mil.), Bihar (7.6 mil.), Haryana (6.1 mil.), Maharashtra (5.6 mil.) and Punjab (5.2 mil.), as presented in Table 12. Only 18 states have more than 0.5 million buffalo population.

Table 12. Statewise population of buffaloes in India in 2012

Sr. No.	State/ UT	Females (Million)				Total Buffaloes (Million)
		< 1 Year	1 to 3 Years	Above 3 Years	Total Female	
	Total Country	**20.155**	**15.858**	**23.671**	**92.599**	**108.702**
1	Uttar Pradesh	5.719	4.559	15.433	25.711	30.625
2	Rajasthan	2.625	1.842	6.933	11.401	12.976
3	Andhra Pradesh	2.036	1.473	5.763	9.272	10.623
4	Gujarat	1.950	1.954	5.646	9.550	10.386
5	M. P.	1.554	1.099	4.251	6.904	8.188
6	Bihar	1.742	0.832	4.016	6.591	7.567
7	Haryana	1.135	1.099	2.914	5.147	6.085
8	Maharashtra	0.875	0.763	3.359	4.998	5.594
9	Punjab	0.870	0.952	2.805	4.626	5.160
10	Karnataka	0.641	0.413	2.056	3.110	3.471
11	Chhattisgarh	0.103	0.089	0.409	0.600	1.391
12	Jharkhand	0.118	0.099	0.389	0.614	1.186
13	Uttarakhand	0.157	0.134	0.582	0.874	0.988
14	Tamil Nadu	0.130	0.128	0.423	0.680	0.780
15	J & K	0.142	0.101	0.416	0.660	0.739
16	Odisha	0.074	0.066	0.250	0.391	0.726
17	Himachal Pra.	0.116	0.117	0.423	0.656	0.716
18	West Bengal	0.046	0.037	0.172	0.254	0.597

Source: Anonymous (2014)

With respect to buffalo milk production, Uttar Pradesh state stands first in the country, followed by Rajasthan, Punjab, Haryana and Andhra Pradesh, as presented in Table 13. It may be observed that, while Uttar Pradesh and Rajasthan maintained their rank because of larger population, Punjab and Haryana stood third and fourth in buffalo milk production, because of superior quality buffaloes of elite buffalo breeds.

Table 13. Share of buffalo milk in India and major states

Sr. No.	States	Milk Production Million Tons	% Share of Buffalo milk
1	Uttar Pradesh	17.524	69.54
2	Rajasthan	8.985	53.06
3	Punjab	7.313	70.65
4	Haryana	6.628	83.88
5	Andhra Pradesh	6.574	68.08

All States Total	146.314	51.06

Source: Anonymous (2014)

11. BUFFALO BREEDS OF INDIA

There are over 20 important breeds of buffaloes (Asian River type) in India, including 10 well-defined breeds, namely Murrah, Nili-Ravi, Jaffarabadi, Surti, Bhadawari, Banni, Mehsana, Marathawadi, Nagpuri, Pandharpuri and Toda. These breeds have been grouped into 5 groups based on their original habitats. Important buffalo breeds and their home tracts are presented in Table 14.

Table 14. Home tracts of important breeds of buffaloes in India

Group	Breeds	States
Murrah	Murrah, Nili- Ravi, Kundi, Godavari	Punjab, Haryana, A. P.
Gujarat	Jaffarabadi, Mahsana, Surti, Banni	Gujarat
Uttar Pradesh	Badhawari, Tarai	Uttar Pradesh, Uttarakhand
Central India	Nagapuri, Pandharpuri, Manda, Marathwada, Kalahandi, Jerangi, Sambalpuri	Maharashtra, Odisha
South India	Toda, South Kanara	Tamil Nadu, Karnataka,

Source: Yadav et al (2017)

12. CHARACTERISTICS OF INDIAN BUFFALO BREEDS

The details of these breeds are presented in Table 15. Murrah is the most popular breed in India. Other popular breeds are Jaffarabadi and Nili – Ravi. Surti buffaloes are small in size. Pandharpuri can tolerate high temperature. Banni, Mehsana and Godavari breeds have originated from Murrah breed and they are popular in their home tracts (Yadav *et al*, 2017). These breeds give a wide option for farmers to make their own choice to upgrade their native animals. Many other breeds such as Kundi, Manda, Marathwada, Kalahandi, Jerangi, Sambalpuri, South Kanara, etc. are almost on the verge of extinction. Specialities of various breeds are presented below.

Murrah: Original home tracts of Rhotak in Hissar, Sindh of Haryana, Nabha and Patiala districts of Punjab, and southern parts of Delhi state. This breed is also known as Delhi, Kundi and Kali. These buffaloes are usually black in colour with white marking on tail. They have short but tightly curved horns. The weight of calf at birth is 32 kg and 30 kg for male and female, respectively. The age at first calving is 45 – 50 months and the inter-calving period is 450 – 500 days. The average height of the adult male and female buffaloes is 142 cm and 133 cm while the length is 150 cm and 148 cm and the body weight is 750 kg and 495 kg, respectively. This breed is an efficient milk producer with milk yield varying between 1500 and 2500 kg per lactation, with 7.83% fat content.

Nili Ravi: This breed originated around Ravi river and is found in Sutlaj valley in Pakistan. Small head, elongated head with wall eyes, small tightly coiled horns, black skin with white markings on forehead, face, legs and tail are typical characteristics apart from body height of 140 cm and 134 cm and weight around 650 kg and 575 kg for male and female respectively.

The females reach the age of 45 -50 months at first caving. Average milk yield is 1500 – 1850, with a calving interval of 500 – 550 days.

Godavari: It is a cross between local buffaloes with Murrah in Godavari and Krishna districts in Andhra Pradesh. The body size is medium and colour is black with coarse brown hair. The milk yield is 1200 – 1500 kg per lactation, with high butter fat. Calving interval is short and the breed is hardier with high tolerance to diseases.

Jaffarabadi: Also known as Bhavanagari, Gir or Jaffari, this breed is found in Gir forests, Kutch, Bhavanagar and Jamnagar districts in Gujarat. It is the heaviest breed with body weight of 700 kg and 530 kg for male and female adults respectively. Body colour is black, but some are with white or grey tail switch. Horns are long, exhibit wide variation, usually emerge out by compressing the head, go downward sideways, then upward and inward, making eyes look small. These animals are generally maintained by traditional breeders known as Maldharis. Average milk yield is 1200 – 1500 kg/ lactation, although highest milk production has been recorded up to 30 kg/day, and fat content of milk upto 18 per cent.

Surti: This breed is also known as Deccani, Gujarati, Talabda, Charatori and Nadiadi. Its breeding tract is Surat, Bharuch, Kaira and Baroda districts of Gujarat. It has black or brown skin, with a coat varying from rusty brown, silver grey to black. Two white bands below the neck - one around the jaw and the other at the brisket region are prominent. Horns are medium sized, flat, sickle shaped, directed downwards and backwards and to turn upwards at the tip. With medium sized body, lighter in body, weighing 400 kg and 435 kg for female and male respectively, this breed consumes less feed and thrives well on crop residues, even without green fodder. Hence it is popular among marginal farmers. Wight of calf at birth is 24 – 26 kg and age at first calving is 45 months. It produces 1000 to 1300 kg milk with high fat content (8 -12 per cent).

Mehsana: Also known as Mehsani, this breed, a cross between Surti and Murrah breeds, is found in Ahmedabad, Banaskantha, Gandhinagar, Mehsana and Sabarkantha districts in Gujarat. Body is longer than Murrah but limbs are lighter. These are mostly black, but brownish or greyish animals are also present. Eyes are prominent, black and bright. Horns are sickle shaped, less curved and irregular. This breed is known for persistent milking and regular breeding. Body height is 128 cm and 134 cm and body weight is 485 kg and 565 kg for female and male, respectively. Milk yield is 1200 – 1500 per lactation, with an inter-calving period of 450 – 550 days.

Banni: This breed also known as Kutchi and Kundi breed, migrated from Afghanistan about 500 years ago and settled on calcareous, saline and loam sandy pasturelands – named as Banni in Kutchh district of Gujarat. The body colour is mainly black while some have copper colour. Horns are medium to large, heavy with 24 to 30 cm diameter, curved, vertical and upward in direction with inverted double / single coiling. Body size is medium to large, compact and covered with hair. Udder is well developed, with milk yield of 1500 -200 kg per lactation.

Bhadawari: This breed also known as Etawah, is found in Bhind and Morena districts in M.P. and Agra and Etawah districts in U.P., in the ravines of Yamuna, Chambal and Utangan rivers.

This is a medium sized breed, with blackish, copper to light copper colour skin, and wheat straw coloured legs. Two white lines are present on the lower side of the neck and tail switch is white or black and white. Horns are black curling slightly outward down, before running parallel, close to neck and finally turning upward. This breed is an efficient converter of coarse feed into butter fat, well known for high fat in milk between 6 to 12.5 per cent. Average milk yield is 800 -1000 kg per lactation. This breed is resistant to diseases and tolerant to heat.

Table 15. Features of Indian buffalo breeds

Breed	Habitat	Age at 1st Calving (M)	Lactation Yield	Characteristics

			(Litres)	
Murrah	Haryana, Punjab, U.P.	45	2000 Fat 7.83%	Black, massive, stocky; heavy bone, horns short, tightly curled; Placid
Jaffarabadi	Saurashtra, Kutch (Guj.)	47	2200 Fat 7.7%	Black, massive, long barrelled confirmation; Horns long heavy, broad, bent towards face to cover eyes
Bhadawari	Agra (UP) Gwalior (MP)	49	1150 Fat 9.0%	Copper colour with a white ring at neck, scanty hair, black at base and brown at top, tail switch is white or black and white; Horns are short and grow backwards.
Surti	Anand, Surat (Gujarat)	50	1300 Fat 8.1%	Black or reddish skin, having 2 chevrons on chest, white markings on forehead, legs and tail; Sickle shaped medium size horns; Long tail with white tuft
Nili Ravi	Firozpur (Punjab)	42	1800 Fat 7.1%	Similar to Murrah, with white marks on extremities and walled eyes, horns less curled, shorter, well shaped udder
Mehsana	Mehsana (Gujarat)	42 - 44	2000 Fat 6.6%	Resemblance is between Murrah and Surti, jet black, sickle shaped horns; Well developed udder with prominent milk veins
Pandharpuri	Solapur, Satara, Sangli and Kolhapur	45	1384 Fat 7.0%	Light to deep black, often with white markings on forehead and legs; Long, sword shaped horns;

	(Maharashtra)			Hardy, thrives well between 9°C and 42°C.
Nagpuri	Nagpur, Wardha (Maharashtra)	36 - 40	900 Fat 7.0%	Black with white patches on face, legs and switch; Flat, long horns, curved back towards shoulder; Short nasal flap

Source: Yadav et al (2017)

Tarai: This breed originated from Murrah in Ramnagar in the hilly Tarai region. The animals are with moderate body, bulged head with prominent nasal bones. Horns are flat, long and coiled, bending backwards, downwards, with pointed tips. Colour of the skin is black to brown, with long tail with white switch. Milk production is slightly low, around 600 - 900 kg per lactation.

Nagpuri: Found in Nagpur, Akola and Amaravati districts of Maharashtra, this breed is also known as Elitchpuri and Barari. Colour of skin is black with white patches on face, legs and tail. Horns are long, flat and curved, bending backside, forming a sword shape. Age at first calving is 45 – 50 months and the milk yield is 700 to 1200 kg per lactation, with a calving interval of 450 – 550 days.

Pandharpuri: Also called as Dharwadi, it is found in Solapur, Satara, Sangli and Kolhapur districts of Maharashtra. Colour of this breed is usually black, but varies from light to deep black. White markings on forehead, legs and tail are found in some animals. Horns are long, sword shaped, sometimes twisted, which measure up to 1 to 1.5 m, extend beyond shoulder blades. Nasal bone is very prominent, long and straight. This breed is very hardy, which thrives well under harsh weather with humidity between 43% and 87% and minimum and maximum temperatures between 9°C and 42°C. The average milk yield is between 700 and 1200 kg per lactation, with a calving interval of 445 days and a peak yield recorded up to 15 kg per day.

Toda: Fond in the Nilgiri Hills of South India, this breed has been named after the ancient Toda tribe. It is a semi-wild breed, with fawn and ash-grey colour and thick hair coat all over the body. The horns are set wide apart curving inwards, outwards and forward, forming a characteristic crescent shape. Body is medium sized, long and deep, with deep chest. Legs are short and strong. They yield 500 kg milk per lactation, with 8 per cent fat content.

South Kanara: Found in Udupi and Mangalore blocks of South Kanara district in Karnataka in the West Coast. Well-built animals with colour varying from brown to silver grey and black. Horns are corrugated, flat and placed backward, sideward and upward. Age at first calving is around 30 -60 months. Milk yield is moderate in the range between 420 and 1000 kg per lactation, with a calving interval between 12 to 36 months.

13. BUFFALO PRODUCTION SYSTEMS

Depending on the number of buffaloes owned and land and fodder resources available, farmers maintain their buffaloes under the following management systems.

These systems are classified as below:

1. Extensive System: Small farm, with 1 to 2 buffaloes maintained on natural grasses on community lands, supplemented with agricultural by-products using family labour and traditional technology;
2. Semi Intensive System: 3 to 5 buffaloes maintained with fodder produced under irrigation, crop by-products and concentrates, with improved housing and care.

3. Intensive: Herd of 5 to 100 or more buffaloes, mostly in Haryana, Punjab, Uttar Pradesh, Rajasthan, Gujarat and peri-urban areas.

The advantages and drawbacks of different systems are presented in Table 16.

Table 16. Advantages of different management systems

Silvipastoral system	Open-air system	Intensive system
Provides natural shade	↑ Time for walking and eating	↓ Space required for production
Allows normal wallowing	↓ Agonistic behaviour	Production of foods of animal origin during scarcity pasture
↑ Non-agonistic interactions such as sniffing and nuzzling	↑ Weight gain	Control of diet
↓ Reduced rectal temperature (39.14 vs. 40 °C)	↑ Weight at slaughter	↑ Use of techniques of milk production used with cattle
↓ Plasma cortisol concentration-2.14 vs 3.38 ng/ml)	↑ Body condition	↓ Lower age at slaughter (400 kg around 15 months of age)
↑ Food consumption	Weight gain of 706 gm /day	
↑ Ruminant movement	↑ Increased production; improved weight gain	
↑ Weight gain with supplements		

Source: Dhanda (2006)

Silvipastoral system provides an opportunity for animals to move around and graze on a wide range of herbs. This is the most economic management system, provided adequate fodder resources are available for grazing. However all the pastures do not provide necessary nutritional requirement. Forage production during dry season will be low and scarcity of feed may provoke fights among animals due to competition. This may also create restlessness among the animals. As the animals move away from the shed, the human contact will be reduced significantly and grooming activities will also be reduced.

Under the intensive system, the animals are maintained in the shed, and well fed to provide nutritional needs, although the cost of feeding and maintenance will be higher. However, as less time for walking increases the period of inactivity, there will not be any scope for wallowing. Stall feeding will reduce the free space for animal movement which will cause stress and increase their agonistic behaviour. This will increase the incidences of kicking, defecating, urinating, pulling teat cup during mechanical milking, etc. Continuous standing on hard floor will increase the incidences of lameness in stall fed animals.

Inspite of various advantages and disadvantages, the system adopted by farmers will be influenced by herd size, labour availability and fodder resources. In recent years, with the availability of efficient breeding services and good market for milk, small farmers are trying to feed their high yielding buffaloes well and many of the small farmers devote their small holdings or lease land from others to cultivate good quality fodder. As no space is available for adequate grazing, farmers tend to take their small herd of animals to the open farmland or orchard and tie them with a long rope to facilitate spot grazing for a short period. Farmers

owning high yielding buffaloes do try to grow or buy fodder to ensure higher production. In fact fodder cultivation can be more remunerative than many cash crops, if the cows and buffaloes fed are high yielders (Hegde, 2018).

14. CHALLENGES OF SMALL BUFFALO FARMERS IN INDIA

Although there are many milk sheds in India where small dairy farmers have taken up dairy husbandry as a successful income generation activity, farmers in many regions suffer from the following problems:

- Poor quality animals: 50 per cent buffaloes are nondescript, low yielding
- Poor reach of critical services
- Poor health status and outbreak of diseases
- Feed and nutritional deficiencies
- Weak marketing network
- Inadequate credit facilities and poor infrastructure

If the programme has to reach the poor and make a positive impact, it is necessary to address these problems.

15. STRATEGY FOR BUFFALO DEVELOPMENT FOR BENEFITTING SMALL FARMERS

Keeping in view the problems faced by small farmers engaged in buffalo husbandry and need to improve the productivity of buffaloes involving small farmers, the following activities should be strengthened (Hegde, 2014).

1. Genetic Improvement

The programme should focus on the following activities:

Production of Superior Quality Bulls: The primary focus of all the State owned and supported farms should be on breed conservation and production of elite bull mothers and bull calves. The farmers maintaining elite herds of buffalo can also be involved in bull calf production through planned breeding with a buy-back guarantee. Identification of superior germplasm should be a continuous process, and the owners of these elite animals should be rewarded and persuaded to spare their animals for breed improvement, by sparing the bull calves and permitting use of females for superior ovulation, by application of MOET (Super ovulation and embryo transfer technology) for production of superior progeny. Progeny testing of sires should be strengthened to aim at use of proven sire semen on a large scale, by using genome technology. This technology will also be helpful for introducing various economic traits in the future progeny.

Production of Superior Quality Semen: The semen freezing laboratories should be registered with the Ministry of Agriculture in different regions for periodic monitoring of their quality. The bulls to be brought under semen freezing, should have certification for their pedigree, performance and disease free status. Production and use of sexed semen should be promoted for ensuring the birth of female calves of high pedigree.

Conservation of Genetic Resources: As most of the farmers owning nondescript buffaloes prefer to upgrade their progeny with a few select breeds such as Murrah and Jaffarabadi, most of the other breeds are neglected and some of the breeds are on the verge of extinction. Hence serious efforts should be made to increase the population of native breeds in their home tracts by preventing the introduction of other breeds and encouraging the farmers to select superior animals for future breed improvement. Simultaneously, studies on economics and utility of different breeds should be undertaken to highlight the importance and special economic traits. Farmers maintaining native breeds should be compensated with incentives and assurance to procure elite animals at a premium, for wider multiplication.

2. Breeding Services and Management

Training and Regulation of AI Technicians: To promote efficient breeding services, available at the doorstep of farmers, skill oriented training should be organised for paravets. The nodal agency can conduct a test for trained paravets before permitting them to operate breeding services privately. To check the quality of the services and to avoid exploitation of the farmers, privately operating paravets can be brought under the supervision of the local Dairy Federation. The State Animal Husbandry Department can monitor the work and arrange advanced training periodically. It is necessary to restrict the movement of paravets to their assigned villages to ensure accountability of their services and to prevent unfair competition.

Support Services: Timely supply of various inputs such as liquid nitrogen, frozen semen, vaccines, first aid kit, vitamins, concentrates, mineral mixture and forage seeds is essential for the success of the paravets. This can be entrusted to the local Dairy Federation or NGO engaged in livestock husbandry. Special programmes should be developed to promote economic management of buffaloes by providing critical inputs and services through their Self Help Groups and assisting in forward and backward linkages.

Improving Reproductive Efficiency: There is scope for introducing technologies such as oestrus synchronisation through hormonal treatments, use of DNA/Gene Markers in the nucleus for selection of superior germplasm, Voluntary Waiting Period (VWP) for breeding buffaloes 60 to 65 days after calving for better pregnancy rate, providing the right kind of housing and protection. Providing showers or foggers with fans or wallowing tanks during the hottest part of the day will help in improving reproductive performance. Balanced feeding with mineral supplements, green fodder and concentrate can restore normal reproductive cycles. The target should be to achieve the conception rate for first insemination at 40 per cent and 77 per cent for third insemination.

Farmers should be encouraged to make use of wall charts, breeding wheels and herd monitors and maintain individual buffalo records for timely detection of oestrous cycle and breed at the right stage. As regularity in conception and short calving interval are most important to achieve a high lifetime milk production, timely follow up to confirm pregnancy should be given due importance. Weaning of calves at birth has shown to decrease the service period. Thus if calving interval is reduced to below 410 days, with a lactation period of 270 to 310 days, the farmers are bound to enhance their net income from buffaloes.

3. Health Care

There is good scope to privatise health care services, particularly in well-established milk sheds. Thus, Farmers' Federations and private entrepreneurs can be encouraged to take up the responsibility of promoting effective health care, which can be monitored by the State Veterinary Department. Private veterinarians should be encouraged to practice in close association with paravets engaged in providing breeding services. This can also enable paravets to take up minor treatments and refer major cases to the veterinary doctor. Facilities should be created for online reporting of disease incidences and outbreaks by the farmers to the District Veterinary Officer directly. Regular testing of buffaloes for infectious reproductive diseases like brucellosis and regular culling of infected animals are essential to maintain a healthy herd. The State Animal Husbandry Department can convert selected veterinary hospitals into specialised units for handling complicated cases referred by the practising

veterinarians. Establishment of Disease Investigation laboratories by the local Dairy Federation or private agencies can be encouraged to analyse the samples collected by paravets. This will help in providing timely and effective services. AHDs may redefine their role with priority for disease surveillance, establishing disease free zones and eradication of important diseases, forecasting of disease outbreaks and awareness on preventive and curative measures for control, sanitation and clean milk production. Research and Development facilities should be strengthened for application of biotechnology for disease diagnosis, production of cost effective vaccines and control of critical diseases. Important diseases infecting the livestock in India are presented in Table 17.

Table 17. Livestock disease outbreaks in India in 2010

Diseases	Species	Outbreaks	Attack	Deaths
Foot & Mouth Disease	Cattle, Buffalo, Sheep, Goat, Swine	422	19982	361
Haem. Sept.	Cattle, Buffalo, Sheep, Goat, Swine	380	9170	2150
Black Quarter	Cattle, Buffalo	369	4707	514
Anthrax	Cattle, Buffalo, Sheep, Goat	84	658	338
Fascioliasis	Cattle, Buffalo, Sheep, Goat	165	317376	96
Enterotoxaemia	Buffalo, Sheep, Goat	138	1609	596

Source: Govt. of India (2017)

4. Housing Management

Small farmers generally maintain 1 to 3 buffaloes in India, and tie their buffaloes at night in small shelters, which are made of mud or thatched walls and thatched or tin roof for protection from rain and wind. The floor of the shed is made of bricks or concrete and the floor is cleaned daily. Attention should be given to maintain a dry soft floor to keep the animals healthy, free from infection and injuries. Generally, no special attention is given to housing for the calf. Ideally, calves should be kept in individual pens, which will be easy to keep clean, and protect from direct sunlight, rain, snow and heat. Separate pens help to monitor their feeding, growth and health status. The calves should have access to fresh and clean water at all times. Buckets for milk and water should be kept outside the pen, in a steady holder within easy reach of the calf. Preparing a bed of dry grass on the floor will prevent growth of germs and parasites. The pen should contain a holder for hay and concentrate, placed above the ground to prevent wastage.

5. Feed Management

Generally, the calf is allowed to suckle, to stimulate milk let down and then the buffalo is hand milked. At the end of milking, some milk is left for the calf to suckle again. Buffaloes are fed concentrate at the time of or after milking, twice a day. The concentrate is generally home-made, using oil cakes and wheat bran. Of late, animal feed is available locally or supplied by the dairy federation. Later, it is fed with 8 to 10 kg green fodder or smaller quantity of wheat straw /other crop residues. After morning milking, buffaloes are let out for grazing and to drink water and wallow in common ponds. They take rest in the afternoon under shady trees. They are fed with concentrate at the time of evening milking followed by feeding of some roughage. The dry matter requirement per buffalo is 10.6 to 16.5 kg/day.

Milk production is better in open air systems, as keeping in shed and stall feeding results in increased lameness, mastitis and agonistic behaviour. Buffaloes prefer pond or ditch to running stream for wallowing. Allocation of greater space will lead to higher milk yield. Balanced nutrition will improve milk yield further. However these is huge scarcity of feed and fodder in the country. In fact, it is the availability of fodder which influences the profitability. There is scope to improve the fodder supply as below.

Improvement of Nutritional Value of Crop residues: Presently, 55 per cent of the total fodder is met from crop residues in India. Major quantity of dry matter is contributed by paddy straw, wheat straw, sugarcane bagasse and trash, which are of poor nutritional value and with high fibre content. With simple techniques, such as chaffing, soaking in water, treating with urea, steaming, etc., nutritive value of such fodder can be improved significantly. This will also help in augmenting fodder shortage, by preventing wastage. There are new varieties of cereal crops, which produce better quality fodder in the form of crop residue, without any decrease in grain yield. Some of the varieties yield larger quantity of fodder without any drop in grain yield. Farmers should be enlightened about cultivation of such dual purpose varieties to support dairy husbandry.

Increase in Forage Yields: Presently, no improved practices are followed for cultivating forage crops. Thus, efforts are needed to breed superior fodder varieties produce and supply good quality seeds, promote use of soil amendments, biofertilisers and forage harvesting equipment, to increase the forage yield and to reduce the cost of production. Fodder crops can be established on field bunds, borders and available wastelands as well, wherever possible.

Development of Community Wastelands: Efforts should be made to develop pasture lands involving local communities, through soil and water conservation, introduction of improved legumes and grasses, forage tree species and prevention of grazing by stray animals. Other common lands, river banks and roadsides can also be used for establishing fodder shrubs and trees.

Complete Feed Rations: To overcome nutritional imbalance in the field and to facilitate small farmers and landless to maintain their livestock under balanced feeding, decentralised complete feed production units can be established. These units can collect all the available biomass suitable for feeding livestock after processing. Such units can use the biomass which are normally not consumed but can be ground and processed through chemical or microbial process and mixed with concentrate to develop a complete feed. Such complete feed can be procured even by landless families keen to maintain animals.

Fodder Banks: Establishment of fodder banks in fodder scarcity regions through Dairy Federations and People's Organisations can help small farmers to feed their livestock during scarcity. In paddy and wheat growing areas where the straw is wasted, facilities for compacting straw should be installed and arrangement should be made to collect and pack them. Fodder banks can play a critical role in timely supply of feed to livestock owners during drought years. However, in the absence of any buyers in good seasons, the stock remains unsold, causing heavy burden for the establishment. Hence, the experiences in the past have not been very encouraging. Therefore linking of complete feed production unit with fodder banks can solve this problem.

Introduction of By-pass Protein Feed: Techniques have been developed to avoid wastage of nutrients by feeding by-pass protein. Support should be provided to establish by-pass protein production units particularly in milk sheds where high quality milch animals are maintained. Bypass fats are now also available to ensure efficient use of this nutrient, which in turn will reduce the cost.

Reduction of Herd Size: It is also necessary to create awareness among farmers to reduce their herd size and ensure optimum feeding instead of keeping a large number of underfed animals. Farmers should be advised to cull unproductive animals from time to time.

6. Capacity Building

Small farmers need support to avail critical services, technical advice and to procure necessary inputs to maintain their dairy animals. The responsibility of providing various services and establishing backward and forward linkages to strengthen the value chain for small farmers should be entrusted to strong local organisations. This role can be assumed by the milk processing units, dairy federations, voluntary organisations or private entrepreneurs in the region, who are committed to the business and the farmers. These nodal agencies can also take up the production of critical inputs such as frozen semen, cattle feed, forage seeds, etc. required by the farmers. Milk processing units should assume a prominent role in promoting breeding services, input supply and health care provision, insurance, working capital, apart from collection of milk. The farmers should be trained in clean milk production.

There is good scope for establishing Mini Dairies and Dairy Parlours in small towns, roadsides and even in villages, to expand the market for dairy products. This will ensure transparency and efficiency, while generating employment at the village level. Marketing of animals is equally difficult and grossly neglected. In the absence of an organised market, farmers are exploited by the traders and middlemen. The market for meat and skin is highly scattered. Hence, direct linkage with processors and consumers should be established.

It is necessary to develop a strong value chain, for effective networking among all the stakeholders engaged in buffalo development. This will help to avoid duplication of efforts and wastage of resources, while enhancing the production.

16. DISCUSSION AND CONCLUSION

Buffalo which ranked first in population and milk production was neglected for a long period even in India, due to poor breeding, health care and marketing infrastructure. It is only during the last two decades that this sector has gained significant importance due to its economic strength over cattle. Buffaloes were presumed to be seasonal breeders with long inter-calving period and their milk was considered to be inferior to cow milk. However several studies have confirmed that buffaloes are hardier than cows with their ability to digest course fibre and good milk yield, even without supplementary feeding of concentrate. Buffaloes have been reported to be year round breeders, although the rate of conception is higher during cool period. Poor conception during other seasons could be attributed to nutritional deficiency during summer, poor oestrous cycle during warmer weather conditions, silent heat, higher rate of infertility of bulls in summer, etc. With intensive management and use of frozen semen for artificial insemination, buffaloes come to heat and conceive all-round the year, ensuring steady supply of milk. With separation of 50 per cent fat, buffalo milk can be more popular than cow milk, because of the quality and taste. This can be a future selling point for buffaloes.

In India, Murrah breed is most famous across the country, while Jaffarabadi and Surti are popular in certain regions. Most of the other breeds are under neglect due to lack of awareness about their economic traits and lower milk yield, compared to Murrah buffaloes. As each breed has a unique feature such as high fat content in milk, heat tolerance, body shape and size, etc. it is necessary to take up genomic study and identify the genes associated with these qualities. Buffaloes are also good source of meat and there is a need to develop suitable production systems under different conditions, particularly on the availability of feed and pastures. Cost of feed is an important factor which affects the profitability. Good dairy farmers are very vigilant about the fodder availability which is also linked with the price and reduce their herd size during the years of fodder shortage. However small farmers owning 1-3 high yielding buffaloes are dependent on semi-intensive system and prefer to produce green fodder, if they are able to realise better price for the milk. Hence suitable support for fodder production will encourage small farmers to improve the productivity further.

Because of the growing demand for buffalo meat, buffalo husbandry is becoming popular in many countries in South America and Asia and India is in a premier position to provide expertise and various inputs. However the immediate priority should be to screen the existing population, cull the unproductive buffaloes and upgrade the low yielding nondescript animals to elite breeds of farmers' choice. Development of suitable kits to detect oestrous cycle,

timely insemination and regular testing against diseases can help in maintaining a healthy and productive stock to boost the profitability.

19. REFERENCES

1. CABI. Invasive Species Compendium: Datasheet on *Bubalus bubalis* (Asian water buffalo). 2018; Accessed 17 October 2018.
2. Rao J. Comparison between cow milk and buffalo milk as per Ayurveda. 2017; Accessed 24 October 2018.
   Available: https:// www.stylecraze.com/articles/
3. Buffalopedia. Buffalo Classification and Breeds. 1999; Accessed 16 October 2018.
   Available: http://www. buffalopedia.cirb.res.in;
   Available: https://www.cabi.org/isc/datasheet/90762.
4. Hays J. Water buffaloes. Facts and details. Asian and Asians- International and Economic Issues. 2008; Accessed 20 October 2018.
5. Borghese A, Mazzi M. Buffalo population and strategies in the world. Buffalo Production and Research. FAO REU Tech. Series. 2005; 67:16- 41.
6. Dhanda OP. Development of Indian Buffalo as Dairy Animal. Proc. 5th ABA Congress, Nanning, China. 2006: 112-119.
7. de la Cruz-Cruz LA, Guerrero-Legarreta I, Ramirez-Necoechea R, Roldan-Santiago P, Mora-Medina P, Hernandez-Gonzalez R, Mota-Rojas D. The behaviour and productivity of water buffalo in different breeding systems: A review. Veterinarni Medicina. 2014; 59 (4): 181–193.
8. Cruz LC. Trends in buffalo production in Asia Ital. J. Anim. Sci. 2007; 6 (Suppl. 2): 9-24.
9. Borghese A. Buffalo production and research. FAO REU Tech. Series; 67: 1- 15; 2005.
10. Anonymous. Top Buffalo Milk Producing Countries in the World. 2017; Accessed 15 October 2018.
    Available: https://www.worldatlas.com/.../top-buffalo-milk-producing.
11. Anonymous. 19th Livestock Census - 2012 All India Report. Ministry of Agriculture Department of Animal Husbandry, Dairying and Fisheries, New Delhi; 2014.
12. Hegde NG. Impact of crossbreeding and upgrading of nondescript cattle and buffaloes on livestock quality and income. Indian J. of Animal Sciences 2018; 88 (5): 606–611.
13. Government of India. Annual Report 2016–17. Dept. of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare. 2017: 3–5.
    Available: http://factsanddetails.com/asian/cat62/sub408/ entry-2830.html
14. Yadav AK, Singh J, Yadav SK. Characteristic features of registered Indigenous Buffalo Breeds of India: A Review. Int. J. Pure App. Biosci. 2017; 5 (4): 825-831.
15. Hegde NG. Promotion of dairy husbandry for sustainable development. In: Gandhian Approach to Rural Prosperity. BAIF, Pune. 2014: 162 – 78.