Review Paper

Buffalo Husbandry for Sustainable Development of Small Farmers in India and other Developing Countries

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ABSTRACT

Aim of this paper is to explore the potential of buffalo husbandry for providing sustainable livelihood to 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 purposes 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. Introduction of breeding services using frozen semen 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 production in other developing

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, 4000 years earlier, 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 [1]. (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. Another reason for neglect of buffaloes was high fat content in milk. 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 [2]. (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. Farmers in India maintained buffaloes for milk, dung and bullock power. As buffaloes were hardier than cows, particularly for their ability to survive on fibrous crop residues, small and poor farmers preferred to maintain buffaloes.

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 reduced fat content before consumption, the economy of buffaloes can surpass cows in all respects. However, buffaloes are poor breeders, as their reproductive efficiency is affected by late maturity, poor expression of oestrous symptoms particularly during summer, irregular oestrous cycle, silent heat, poor conception rate, early embryonic mortality and prolonged inter-calving interval [3] (Phogat *et al* 2016). Many of these concerns have been addressed through scientific interventions in the recent past. However, there is a wide gap between the available scientific knowledge and the understanding of buffalo owners in India. Hence, this study was undertaken to review the current status of buffalo population, production practices and challenges faced by small farmers in increasing milk production, and to suggest suitable management practices to improve their economy.

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)

2.2. Types of Asian Buffaloes

Among Asian buffaloes, there are two subspecies namely Swamp type with 48 chromosomes and River type with 50 chromosomes (Buffalopedia, 1999). 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 up to 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 crossing 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.

Types of Buffaloes Maintained in Different Countries: 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 had the second largest number of Swamp buffaloes in the world. However, the population has drastically declined from 4.7 million in 1990 to 1.9 million in 1998. In Vietnam, there are only Swamp buffaloes, used for bullock power and meat. 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 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. 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, having a smaller body size, with an average milk yield of 1825 kg/lactation. Buffaloes in India are maintained primarily for milk production (Yadav *et al*, 2017).

3. WORLD BUFFALO POPULATION AND MILK PRODUCTION

In 2012, world buffalo population was 199.8 million, as compared to cattle population of 1428 million, as presented in Table 1 (FAO, 2015). Between the years 1970 and 2010, buffalo population had increased by 32 per cent, as compared to 81 per cent increase in cattle. However, the total world bovine population reduced from 1622 million in 2010 to 1002 million in 2018, recording a steep reduction of 38 per cent in eight years. This reduction was due to significant reduction in cattle population, while the buffalo population increased to 216 million. In India, the bovine population marginally increased by 1.8 per cent, from 299.6 million in 2012 to 305 million in 2018 (Cook, 2015; Cook, 2019).

Table 1. World livestock population

Livestock Species	1970 (Million)	2000 (Million)	2013 Million	% Change (2000 - 2013)
Cattle	1081	1,302.9	1494.3	114.7
Buffaloes	107	164.1	199.8	121.8
Sheep	1063	1059.1	1172.8	110.7
Goats	377	751.6	1005.6	133.8
Total Bovine	1188	1467.0	1694.1	115.5

Source: FAO (2015)

By 2017. the world buffalo population had increased marginally to 201 million, of which 97 per cent were in Asia (Borghese, 2005; FAO, 2019) and only 3 per cent were spread over other continents (Table 2). India had 56.4 per cent of the world buffalo population, followed by Pakistan (18.8 per cent) and China (11.7 per cent). The annual population growth of buffaloes in the world has been at 0.8 per cent between 1991 and 2002 and 1.3 per cent during 2002 to 2017, indicating a growing interest in buffalo husbandry during recent years. Other countries having significant buffalo population are presented in Table 3 (FAO, 2019). These buffaloes have been maintained for milk production. Largest buffalo population in South America was in Brazil (3.0 million), followed by Colombia (0.3 million) and Venezuela (0.15 million). There was a significant increase in population of buffaloes from 30,000 to 0.3 million in Colombia during the last 10-15 years, for meat production. The government has promoted Colombian Association of Buffalo Breeders (Asociacion Colombiana de Criadores de Bufalos - ACB) to facilitate veterinary services and marketing. There are many farms maintaining over 500 - 1000 buffaloes on grazing system on private pastures (Personal communication with ACB, 2018).

Table 2. Buffalo population: Ranking of countries in Asia

Rank	Countries	1991 Million	2002 Million	2017 Million	Growth in % 2002 to 2017
1	India	84.206	95.100	113.330	19.17
2	Pakistan	18.273	24.000	37.700	57.08
3	China	22.024	22.249	23.469	5.48
4	Nepal	3.058	3.701	5.178	39.91
5	Myanmar	2.101	2.552	3.747	46.83
6	Philippines	2.577	3.122	2.882	- 7.69
7	Vietnam	2.887	2.815	2.492	-11.48
8	Bangladesh	0.832	0.830	1.478	78.07
9	Indonesia	3.342	2.300	1.395	- 39.35
10	Lao PDR	1.130	1.060	1.189	12.17
11	Thailand	4.728	1.800	0.996	- 44.67
12	Cambodia	0.804	0.626	0.655	4.63
13	Sri Lanka	0.896	0.661	0.284	-57.04
14	Malaysia	0.194	0.154	0.119	- 22.73
	Asia & Pacific	147.064	160.980	194.914	20.78
	World	153.104	167.126	201.000	21.08

Source: Borghese (2005) and FAO (2019)

With regard to milk production by buffaloes in the world, out of 102 million tonnes produced during 2013-14, 99.22 million tonnes were produced in Asia and India contributed 70 million tonnes, as presented in Table 4 (Anonymous, 2018). During the same year, buffaloes contributed 3.72 million tonnes of meat, of which 89 per cent was produced in Asia ad 43 per cent in India. The beef production increased further in 2015 to 4.3 million tonnes (Wikipedia - Buffalo meat, 2019).

Table 3. Buffalo population in other countries

Sl. No.	Countries	2017 No. of Buffaloes
1	Egypt	3375727
2	Brazil	1381395
3	Italy	400792
4	Colombia	300000
5	Iraq	209163
6	Azerbaijan	196651
7	Venezuela	150000
8	Turkey	142073
9	Iran	126765
10	Timor -Lese	124208
11	Georgia	18358
12	Tajikistan	15259
13	Bulgaria	12273
14	Kazakhstan	10382
15	Germany	8674

Source: FAO (2019)

Table 4. Ranking of countries producing buffalo milk

Rank	Country	Milk Production in 2013-14 (Million Tonnes)
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 (2018)

4. ECONOMIC ADVENTAGES 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 buffalo is as good as Holstein Friesian cow among buffaloes. Buffalo milk with 7 to 8 per cent fat and 3.5 to 4.0 per cent proteins, is richer in quality than cow milk. Comparative nutritive value of milk of cow and buffalo are presented in Table 5 (Dhanda, 2006). Buffalo calf can achieve weight gain of 800 gm per day without any supplementary feed, resulting in low cost of production (Cruz, 2007).

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 movement, 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 to 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).

Table 5. 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. GROWTH HABIT AND MATURITY IN BUFFALOES

Generally, female buffalo calves attain puberty at 36 to 42 months of age, although with good feeding and health care, 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 (Wikipedia- Italian, 2018).

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 (Borghese and Mazzi, 2005).

Buffaloes come in heat regularly in all the months, the highest being in October and the lowest in April. However, around 75 per cent of the total calving has been taking place during July to January, suggesting seasonal breeding tendency (Singh and Barwal, 2010). The average age at first calving in Murrah and Nili Ravi was between 40 and 45 months, while it was higher at 46 to 54 months in Surti and Bhadawari and lower - between 38.4 and 39.8 months in Pandharpuri buffaloes. The calving interval in Murrah and Nili Ravi buffaloes varied between 480 to 573 days while it was 525 days in Bhadawari and 462 days in Surti buffaloes. The lactation length in Murrah buffaloes ranged from 245 days to 355 days, while it was 300 to 356 days in Nili Ravi and Surti buffaloes, 376 days in Bhadawari, 310 days in Marathwada and 200 days in Nagpuri buffaloes.

Shivahre and others (2017) reported that age at semen collection in Murrah buffalo bull calf was 1073.5±28.41 days. Age at first semen collection was not significantly affected by season of birth in Murrah buffalo bulls. This period can be reduced by introducing the young male

calves to training at an early age. Better management practices can further improve the reproductive performance of buffalo breeding bulls.

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. They spend 59 per cent time on grazing, 28 per cent time on rumination, 27 per cent time on resting and 13 per cent time on wallowing during the day (de la Cruz-Cruz *et al*, 2014). 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 to 25 per cent. However, there a few breeds of buffaloes such as Nagpuri, which can withstand heat up to 47^0C, without drop in milk production (Wikipedia - Nagpuri, 2018).

6. REPRODUCTIVE INEFFICIENCY IN BUFFALOES

Reproductive inefficiency is a major problem in buffaloes, which includes delayed puberty and low fertility, higher age at first calving and longer calving intervals. The major reasons for higher age at puberty were poor feeding and lack of health care, particularly control of ecto and endo-parasites (Dhanda, 2006). Perumal *et al.* ~~and others~~ (2013) reported that seasonal variation, nutrition, congenital defect, hormonal changes and hereditary factor play a critical role in determining the reproductive efficiency in buffalo bulls, while venereally transmitted infection causes early embryonic death and infertility or sterility in female animals. In India, season of calving had a profound effect on service period and buffaloes calving in late winter and early summer had lower reproductive efficiency compared to those calved during other periods. Jamuna *et al*. ~~and others~~ (2016) reported that fertility was negatively associated with production traits in Murrah buffaloes. Phogat *et al.* ~~and others~~ (2016) observed a strong influence of bio-meteorological factors such as day length, ambient temperature, relative humidity and rainfall on the endocrine system of buffaloes. This was reflected in seasonal pattern in breeding efficiency. Thus, poor reproductive efficiency during summer was attributed to shortage of green fodder. They also observed a significant correlation of anoestrus with mean maximum and minimum air temperature and mean relative humidity. The incidences of buffaloes exhibiting oestrus during the short day length period were significantly greater than during the period of long day length in summer. They reported that in the equatorial zone, buffaloes can show oestrous cycle throughout the year, provided adequate nutrition is provided to maintain the reproductive efficiency.

Postpartum uterine health will influence the reproductive and productive efficiency of buffaloes, as even low grade injuries and infections may cause delayed uterine involution and postpartum ovulation and reduced conception rate. Post-partum anoestrous (PPA) has been a major reproductive problem, as only 34 to 49% of buffaloes showed oestrus during the first 90 days after calving, while 31 to 42% remained anoestrus for more than 150 days (Ojha *et al*, 2017). Underfeeding and high temperature stresses are the main causes of long anoestrous and anovulatory periods. It was also observed that buffaloes calving in the rainy season had shorter anoestrous periods (Khan *et al*, 2009). Ghosh *et al.* ~~and others~~ (2015) reported that the levels of vitamin E, and β-carotene in hemolysate were significantly higher in cyclic animals than postpartum anoestrous animals and suggested that the low antioxidant level in affected animals may cause PPA condition. They concluded that stress imposed by pregnancy and lactation was responsible for poor reproductive performance in PPA animals.

Factors affecting Fertility: Buffaloes have several problems which affect their reproductive efficiency. Major infertility problems are presented below (Phogat *et al,* 2016; Kadam, 2018):

- 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 prominent signs of heat stress in buffaloes were decreased feed intake, increased reddening of hide, protruding tongue, panting, obvious bloodshot eyes, increased rectal temperature and increased incidences of mastitis, retained placentas, metritis, and ketosis (Ahmad and Tariq, 2010). Heat stress can also reduce constituents in milk, growth rate and breeding efficiency of female buffaloes, through reduced intensity and duration of oestrus. Buffaloes fail to exhibit oestrus as a result of ovarian inactivity during summer (Kumar *et al*, 2018). 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 shower and wallowing facilities have increased conception rate. Buffalo bulls are most fertile in spring, with highest semen quantity, sperm count and vitality.
- Generally, 80 per cent buffaloes in India were calving during June to December, causing a decline in milk production from March to June. Thus, buffaloes were considered to be seasonal breeders, but it has now been realised that they can be bred year round with good management.

7. 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 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 females increased from 21 million in 1951 to 56.6 million in 2012 as presented in Table 6 (Anonymous, 2014).

Table 6. Population of buffaloes in milk production in India

Year	Total Bovines Million	Adult Female Cattle Million	Adult Female Buffalo Million	% 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)

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. These initiatives helped to conserve precious buffalo breeds and to increase the milk production in the traditional buffalo tracts, but there was no significant impact in other regions as most of the farmers owned low yielding nondescript buffaloes and the conception rate using liquid semen was low (Hegde, 2018). Cryopreservation of buffalo semen was successful due to damage of spermatozoa during cryo-preservation. In the 1970s, technology was perfected to freeze buffalo semen, which led to buffalo genetic improvement on a massive scale (Mughal *et al*, 2017). In India, frozen semen was introduced in late 70's and paravets were trained to provide breeding services at the doorsteps of buffalo owners, at an appropriate stage of heat. This enabled small farmers owning poor quality nondescript buffaloes to produce superior progeny without heavy investment, while reducing unproductive animals (Hegde, 2018). It was reported that 95 per cent buffalo owners in Punjab and Haryana resorted to Artificial Insemination and 82 per cent inseminated their buffaloes at mid heat stage. 70 per cent buffalo keepers followed pregnancy diagnosis (Khadda *et al*, 2017).

Table 7 presents the increase in milk production in India from 2000 to 2016 and the contribution of buffaloes to boost the production (Govt. of India, 2017). It may be observed that in spite 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 about 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. Kaware and Yadav (2014) reported that income from crossbred cows was 32 per cent higher than that of buffaloes, because of higher milk yield. The cost of buffalo milk production was also 102 per cent higher as compared to cost of producing cow's milk. However, Meena and Jain (2012) observed that buffalo milk production is more profitable than cow in Rajasthan, where a majority of the cattle were of native breeds. In Haryana, farmers who sold their surplus buffaloes felt empowered with surplus cash and were motivated to adopt improved buffalo husbandry practices to enhance the productivity (Dixit *et al*, 2017). The contribution of different categories of milch animals to National milk production is presented in Table 8. The average milk production of buffaloes of recognised breeds was 5.76 kg per day while yield of nondescript buffaloes was 3.8 kg/ day, marginally better than elite cow breeds (Govt. of India, 2017).

Table 7. Milk production in India: Contribution by buffalo

Years	Cow Milk Million tonnes	Buffalo Milk Million tonnes	Goat Milk Million tonnes	Total Milk Million tonnes	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 8. Species wise 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)

8. DISTRIBUTION OF BUFFALOES IN INDIA

Out of 109 million buffaloes, Uttar Pradesh has the largest population of 30.6 million buffaloes and only 18 states have more than 0.5 million buffalo population, as presented in Table 9 (Anonymous, 2014).

Table 9. State-wide 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 and Punjab, as presented in Table 10. 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 elite buffalo breeds.

Table 10. Share of buffalo milk in India and major states

Sr. No.	States	Milk Production Million Tonnes	% 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)

9. 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 11 (Yadav *et al,* 2017; Dhanda, 2006) . The details of these breeds are presented in Table 12. Murrah is the most popular breed in India. Other popular breeds are

Jaffarabadi and Nili – Ravi. Surti is a small breed. Pandharpuri can tolerate high temperature. Banni, Mehsana and Godavari breeds have originated from Murrah breed, which 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.

Table 11. 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); Dhanda (2006)

9.1. Characteristics of Major Indian Buffalo Breeds

Murrah: Home tracts of Murrah breed are 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. Murrah buffaloes are usually black, 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 to 50 months and the inter-calving period is 450 to 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 Sutlej valley in Pakistan. Typical phenotypically characteristics are small head, elongated head with wall eyes, small tightly coiled horns, black skin with white markings on forehead, face, legs and tail, with body height of 140 cm and 134 cm and weight around 650 kg and 575 kg for male and female respectively. The age at first calving is 45 to 50 months and calving interval is 500 – 550 days. Average milk yield is 1500 – 1850 kg per lactation.

Godavari: It is a cross of 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 of 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 to 1500 kg/ lactation, although the highest milk production has been recorded up to 30 kg/day, and fat content of milk is up to 18 per cent.

Surti: Also known as Deccani, Gujarati, Talabda, Charatori and Nadiadi, this breed originated in 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 downward and backward and to turn upward at the tip. With medium to 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. Weight of calf at birth is 24 to 26 kg and age at first calving is 45 months. It produces 1000 to 1300 kg milk with high fat content (8 to 12 per cent).

Mehsana: Also known as Mehsani, this breed is a cross between Surti and Murrah breeds, found in Ahmedabad, Banaskantha, Gandhinagar, Mehsana and Sabarkantha districts of Gujarat. Body is longer than Murrah but limbs are lighter. This breed is black, but brownish or greyish animals are also found. 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 to 1500 per lactation, with an inter-calving period of 450 to 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. It is mainly black in colour, while some have copper colour, medium to large in size, compact and covered with hair. Horns are medium to large, heavy with 24 to 30 cm diameter, curved, vertical and upward in direction with inverted double / single coiling. Udder is well developed, with milk yield of 1500 to 2000 kg per lactation.

Bhadawari: This breed also known as Etawah, is found in Bhind and Morena districts of M.P. and Agra and Etawah districts in U.P., in the ravines of Yamuna, Chambal and Utangan rivers. Medium in size, with blackish, copper to light copper colour skin, and wheat straw coloured legs, two white lines on lower side of the neck, with white or black and white tail switch, this breed is resistant to diseases and tolerant to heat. Horns are black curling slightly outward down, before running parallel, close to neck and finally turning upward. Bhadawari is an efficient converter of coarse feed into butter fat, with an average milk yield of 800 to1000 kg per lactation and high fat up to 12.5 per cent.

Tarai: Originated from Murrah in Ramnagar in the hilly Tarai region, with moderate body, bulged head with prominent nasal bones. Horns are flat, long and coiled, bending backward and downward, with pointed tips. Colour of the skin is black to brown, with long tail and white switch. Milk production is slightly low, around 600 to 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 to 50 months and the milk yield is 700 to 1200 kg per lactation, with a calving interval of 450 to 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, measuring up to 1 to 1.5 m and extendimg beyond shoulder blades. Nasal bone is very prominent, long and straight. This breed is very hardy, and 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: Found in the Nilgiri Hills of Tamil Nadu, 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 inward, outward and forward, forming a characteristic crescent shape. Body is medium sized, long and deep, with deep chest and short and strong legs. Average milk yield is 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 of 420 and 1000 kg per lactation, with a calving interval between 12 to 36 months.

Table 12. Features of Indian buffalo breeds

Breed	Habitat	Age at 1st Calving (Months)	Lactation Yield (Litres)	Characteristics
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 backward.
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%	Resembles Murrah and Surti, jet black, sickle shaped horns; Well developed udder with prominent milk veins
Pandharpuri	Solapur, Satara, Sangli and Kolhapur (Maharashtra)	45	1384 Fat 7.0%	Light to deep black, often with white markings on forehead and legs; Long, sword shaped horns; 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); Dhanda (2006)

10. 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 13 (Dhanda, 2006).

Table 13. 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 ↑ Body condition	↑ Use of techniques of milk production used with cattle
↓ Plasma cortisol concentration-2.14 vs 3.38 ng/ml)	Weight gain of 706 gm/day	↓ Lower age at slaughter (400 kg around 15 months of age)
↑ Food consumption ↑ Ruminant movement ↑ Weight gain with supplements	↑ Increased production; improved weight gain	

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 tussle among animals due to competition. This may also create restlessness among the animals. As the animals move away from the shed, the human contact is reduced significantly and grooming activities are also 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 incidences of lameness in stall fed animals (Dhanda, 2006).

Khadda and others (2017) observed that in the Panchmahals district of central Gujarat the buffaloes reared under semi intensive system of management were allowed to graze along road side, community lands, forest lands and fallow fields for 4 to 6 hours daily, depending on the availability of grass. Feeding of common salt and mineral mixture, apart from concentrate, particularly for lactating buffaloes helped to maintain good body conditions and higher productivity. The age at puberty and seasonality in breeding were less in heifers raised under the pasture system. Feeding of minerals was further helpful to induce early oestrus in heifers (Bodla *et al*, 2017).

In spite of various advantages and disadvantages, the system adopted by farmers is influenced by herd size, labour availability and fodder resources. Feeding of a special ration to pregnant buffaloes resulted in birth of healthy calves. 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 these farmers devote their small holdings or lease land from others to cultivate good quality fodder. Bodla and others (2017) observed that specially formulated concentrate mixture (CP 22%) at 2.0 to 2.5 kg/day during pre-partum, significantly improved the total dry matter intake and body condition score of pregnant buffaloes. Concentrate supplementation during postpartum period also improved feed intake,

body condition, lactation and reproductive health, including the conception rate. Savsani and others (2017) observed that supplementation of 10 gm bypass fat per litre per day was found to be effective to increase the milk yield and the profit margin in Jaffrabadi buffaloes. However, higher level of bypass fat at 20 gm and 30 gm did not seem to have any economic advantage.

Due to lack of space 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).

11. BUFFALO DEVELOPMENT FOR BENEFITTING SMALL FARMERS

Challenges of Buffalo Farmers: Although there are many milk sheds in India where small dairy farmers have taken up dairy husbandry as a successful income generation activity, small farmers owning buffaloes in many regions are suffering 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

Keeping in view these problems, the following activities should be strengthened (Hegde, 2014).

11.1. Genetic Improvement

The program 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.

11.2. 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 Civil Society Organisation 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 treatment and 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. Showering of buffaloes twice a day, wallowing and supply of cool drinking water can reduce the heat stress, increase conception rate from 21 to 30 percent and increase the yield by 20 to 25% (Ahmad and Tariq, 2010). The feeding of antioxidants during summer can also improve health and fertility rate. 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. Oestrous synchronisation is a useful technology to improve the breeding efficiency. In a field study, three groups of Murrah buffaloes synchronized for oestrus with different treatments, namely 1. Cosynch treatment - buserelin acetate 10 µg (i.m.) on day 0 and 9, cloprostenol 500 µg (i.m.) on day 7 followed by FTAI at the time of second buserelin acetate and 24 hour later; 2. Porgestomet ear implants subcutaneously for 9 days, estradiol benzoate 2 mg (i.m.) on the day of implant insertion, PMSG 400 IU and cloprostenol 500 µg (i.m.) on day 9 followed by AI at 48 and 72 hours after implant removal; 3. Cosynch-plus - Cosynch protocol as per Group 1 except an additional injection of PMSG 400 IU (i.m.), three days before the start of protocol and FTAI done at the same time as per group 1, led to the conclusion that all the three treatment protocols can be effectively used for induction of oestrus with acceptable conception rate in postpartum anoestrus buffaloes during breeding season under field conditions. However, Cosynch-plus protocol had higher rate of pregnancy (Kumar *et al*, 2016). Suvarn and others (2017) reported that repeated dosages of progesterone on alternate days was very effective in inducing oestrous cycle in buffaloes which were in anoestrous condition even one year after calving.

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 less than 410 days, with a lactation period of 270 to 310 days, the farmers are bound to enhance their net income from buffaloes.

11.3. 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 in disease diagnosis, production of cost effective vaccines and control of critical diseases. Important diseases infecting the livestock in India are presented in Table 14 (Govt. of India, 2017).

Table 14. Livestock disease outbreaks in India in 2010

Diseases	Specie	Outbreaks	Attacks	Deaths
Foot & Mouth Disease	Cattle, Buffalo, Sheep, Goat,	422	19982	361
Haem. Sept.	Cattle, Buffalo, Sheep, Goat,	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)

11.4. 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 of 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 (Dhanda, 2006).

11.5. 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 milking 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 8 to 10 kg green fodder or smaller quantity of wheat straw /other crop residues. After milking in the morning, 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 milking in the evening 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, there 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 required 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 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.

11.6. 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.

12. SUMMARY

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 cooler period. Poor conception during other seasons can 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. 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. 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 popular 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. 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 a good source of meat and there is a need to develop suitable production systems under different conditions, particularly based 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. The growing demand for buffalo meat has led to the popularity of buffalo husbandry in many countries in South America and Asia and India is in a premier position to provide expertise and various inputs.

13. 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.
3. Phogat JB, Pandey AK and Singh I. Seasonality in Buffaloes Reproduction. International Journal of Plant, Animal and Environmental Sciences. 2016: 6 (2): 46-54 Available: https:// www.stylecraze.com/articles/
4. 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.
5. Hays J. Water buffaloes. Facts and details. Asian and Asians- International and Economic Issues. 2008; http://factsanddetails.com/asian/cat62/sub408/entry-2830.html. Updated in April 2014. Accessed 20 October 2018.
6. 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.
7. FAO. Statistical Pocketbook. 2015; 30
8. Cook R. World Cattle Inventory: Ranking of countries (FAO). August 2, 2015. https://www.drovers.com/article/world-cattle-inventory-ranking-countries-fao
9. Cook R. World cattle inventory by country in 2018. Feb 2, 2019. www.beefmarketcentral.com/story-world-cattle-inventory. Available: http://factsanddetails.com/asian/cat62/sub408/ entry-2830.html
10. Borghese A. Buffalo production and research. FAO REU Tech. Series; 67: 1- 15; 2005.
11. FAO. World buffalo population in 2017. http://www.fao.org/fd8ce742-c531-4111-9ff0-daee56ac3de1; 2019.
12. Anonymous. Top Buffalo Milk Producing Countries in the World. 2017; Accessed 15 October 2018. Available: https://www.worldatlas.com/.../top-buffalo-milk-producing.
13. Wikipedia -Buffalo meat. en.wikipedia.org/wiki/Buffalo_meaton. Edited on 28.1.2019
14. Dhanda OP. Development of Indian Buffalo as Dairy Animal. Proc. 5th ABA Congress, Nanning, China. 2006: 112-119.
15. Cruz LC. Trends in buffalo production in Asia Ital. J. Anim. Sci. 2007; 6 (Suppl. 2): 9-24.
16. Wikipedia- Italian Mediterranean buffalo. en.wikipedia.org/wiki/Italian_Mediterranean_buffalo. Last edited on 18.12. 2018.
17. Borghese A, and Mazzi M. Buffalo population and strategies in the world. Buffalo Production and Research. FAO REU Tech. Series. 2005; 67:16- 41.
18. Singh CV and Barwal RS. Buffalo Breeding Research and Improvement Strategies in India. Proceedings 9th World Buffalo Congress 2010:1024–1031.
19. Shivahre PR, Gupta AK, Panmei A, Chakravarty AK, Bhakat M, Dash SK,. Sahoo SK, Kumar V and Singh M. 2017. Effect of non-genetic factors on semen production characteristics of Murrah buffalo bulls at organised semen station. Buffalo Bulletin.36 (1): 114-122.
20. 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.

21. Wikipedia - Nagpuri (buffalo). en.wikipedia.org/wiki/Nagpuri_(cattle).Last edited on 15 March 2018.
22. Perumal P, Kiran Kumar T and Srivastava SK. Infectious causes of infertility in buffalo bull (*Bubalus bubalis*). Buffalo Bulletin, 2013; 32 (2): 71 -82.
23. Jamuna V, Chakravarty AK, Kumar V, Mir MA and Vohra V. Standardizing pregnancy rate of Indian Murrah buffaloes for higher milk yield. Buffalo Bulletin. 2016; 35(1): 109-199
24. Ojha BK, Dutta N, Singh SK, Pattanaik AK, and Narang A. 2017. Effect of pre and post-partum supplementation to buffaloes on body condition, lactation and reproductive performance. Buffalo Bulletin. 36 (1):63-72
25. Khan HM, Bhakat M, Mohanty TK, Gupta AK, Raina VS and Mir MS. Peripartum Reproductive Disorders in Buffaloes - An overview. www.vetscan.co.in and www.kashvet.org; 2009; 4(2): Article 38
26. Ghosh M, Gupta M, Kumar R, Kumar S, Balhara AK and Singh I. Relation between antioxidant status and postpartum anestrous condition in Murrah buffalo. Veterinary World, 2015; EISSN: 2231-0916: 11063-1166.
Available at www.veterinaryworld.org/Vol.8/ctober-2015/1.pdf
27. Kadam S. Breeding Behaviour of Buffaloes in India. 2018.
Available: www.notesonzoology.com/india/dairy/breeding-behaviour-of buffaloes
28. Ahmad S and Tariq M. Heat stress management in Water Buffaloes: A Review. Revista Veterinaria; 2010; 21 (1): 297 pp
29. Kumar VS, Kumar RP, Harikrishna CH and Rani MS. Effect of heat stress on production and reproduction performance of buffaloes - A review. The Pharma Innovation Journal 2018; 7(4): 629-633.
30. Anonymous. 19th Livestock Census - 2012 All India Report. Ministry of Agriculture Department of Animal Husbandry, Dairying and Fisheries, New Delhi; 2014.
31. 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.
32. Mughal DH, Ijaz A, Yousaf MS, Wadood F and Farooq U. Cryo-preservation of buffalo semen – Limitations and expectations. Buffalo Bulletin 36 (1):114.
33. Khadda BS, Lata K, Singh B, and Kumar R. 2017. Study of buffalo husbandry practices in rural area of central Gujarat in India.. Buffalo Bulletin.3 (1): 74-87.
34. Government of India. Annual Report 2016–17. Dept. of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare. 2017: 3–5.
35. Kaware SS and Yadav DB. Economic analysis of milk production in Western Maharashtra. International Research Journal of Agricultural Economics and Statistics. 2014; 5 (1): 55-59.
36. Meena GL and Jain DK. Economics of Milk Production in Alwar District (Rajasthan): A Comparative Analysis. International Journal of Scientific and Research Publications. 2012; 2 (8): 1-5.
37. Dixit VB, Bharadwaj AK, Singh P, Tripathi H and Duhan A. Farmers' Perception about Impact of Sale of Buffaloes on Dairy Development Index and Socio-economic Conditions in Haryana. Indian Journal of Extension Education. 2017; 53 (3): 50-53.
38. Bodla MT, Anwar M, Ahmad E, Naseer Z, and Ahsan U. 2017. Effect of two management systems and mineral feeding on age at puberty in Nili-Ravi buffalo heifers. Buffalo Bulletin.36 (1):27-33.
39. Savsani HH, Murthy KS, Gajbhiye PU, Vataliya PH, Dutta KS, Gadariya MR, and Bhadaniya AR. 2017. Economics of rumen bypass fat feeding on cost of milk production, feeding and realisable receipts in lactating Jaffarabadi buffaloes. Buffalo Bulletin 36 (1): 199-205
40. Hegde NG. Promotion of dairy husbandry for sustainable development. In: Gandhian Approach to Rural Prosperity. BAIF, Pune. 2014: 162 – 78.
41. Kumar L, Phogat JB, Pandey AK, Phulia SK, Kumar S and Dalal J. Estrus induction and fertility response following different treatment protocols in Murrah buffaloes under field conditions. Vet World. 2016; 9(12):1466–1470.
42. Suvarn D, Singh C and. Ansari MM. Study on the responses of progesterone administration on resumption of cyclicity on post-partum anoestrous buffaloes. Buffalo Bulletin. 2017; 36 (1): 96-103.