



## Spatio-temporal dimensions of draught cattle and buffaloes in Tamil Nadu

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### ABSTRACT

Use of animal power generally enables farmers in Tamil Nadu as well India to increase agricultural production. The present study was conducted to explore the spatio-temporal dimensions in draught cattle and buffalo population in Tamil Nadu. Conventional analysis like mean and percentages were used for the present study. Apart from these analyses, the annual compound growth rates (ACGR) of livestock population were calculated. The scenario on cattle and buffalo population over different census periods, their compositional change, status of breed-wise cattle and population, temporal analysis on work animal population and their share to total cattle and buffalo population, scenario of draught animal population density, availability of draught animal power, district-wise variations in draught cattle and buffalo population for the state of Tamil Nadu were worked out and discussed. As a whole, the draught cattle and buffalo population in Tamil Nadu was found decreasing over years, and strategies for improvement of draught animal power in Tamil Nadu was proposed.

**Key words:** Animal power, Draught buffalo, Draught cattle, Tamil Nadu, Work animal

Draught animal power is a consistent and popular farm power resource in most developing countries, especially in Indian rural economy. Majority (89%) of the farmers had favourable attitude towards utilization of draught bullocks in Tamil Nadu, which might be due to the reason that the farmers by and large still depend on bullocks for certain farm operations and they strongly believe that nothing could replace the performance of the bullocks (Akila and Chander 2009). At present, the mechanical source of agricultural power is dependent on fossil fuel that has only limited life. According to current estimates, India's petroleum and natural gas resources may last for only 25–30 years and coal for 130–140 years (Sastri and Thomas 2005). It was estimated that the draught animal power saved about 20 million tonnes of petroleum per year (Shisode *et al.* 2010). The working group on Animal Husbandry and Dairying, 11th Five year plan (2007–12), Government of India, observed that cattle was the main source of draught power for agriculture and allied operations and would continue to remain important. Hence, there is a need for improving the work efficiency of the bullocks. A vast herd of about 80 million bullocks and male buffaloes together provide approximately 32,000 million watts of power and help to

cultivate 90 million farm holdings which accounts for approximately 65% of the total cultivable area of the country (Shisode *et al.* 2010). The value produced by draught animals in India would be over Rs 1,000 billion (Akila and Chander 2009). In this context, the present study was conducted to explore the spatio-temporal dimensions in draught cattle and buffalo population in Tamil Nadu.

### MATERIALS AND METHODS

Conventional analysis like mean and percentages were used for the present study. Apart from these analyses, the annual compound growth rates (ACGR) of livestock population were calculated by using the following formula of point to point growth rate as used by Selvakumar (1996) and Meganathan *et al.* (2004).

$$G = \{ e^{[\ln(Y_t/Y_0)]/t} - 1 \} \times 100$$

where, G, annual compound growth rate;  $Y_0$ , population of livestock species in base year;  $Y_t$ , population in the  $t^{\text{th}}$  year (current year); t, number of years (current year-base year).

The density of the draught animal population was worked out using the formula as

$$\text{DAP density} = \frac{\text{Number of draught animals}}{\text{Gross cropped area in hectares}}$$

### RESULTS AND DISCUSSION

*Cattle and buffalo population in Tamil Nadu over different census periods:* The scenario of cattle and buffalo

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Table 1. Cattle and buffalo population in Tamil Nadu (1951–2007) – in numbers

Year	Cattle	ACGR%	Buffalo	ACGR%	Total bovines	ACGR%
1951	10216260	-	2297162	-	12513422	-
1956	9698251	-1.04	2040944	-2.34	11739195	-1.27
1961	10825903	2.22	2594271	4.91	13420174	2.71
1966	10859345	0.06	2724017	0.98	13583362	0.24
1974	10572378	-0.33	2853253	0.58	13425631	-0.15
1977	10801119	0.72	3077678	2.56	13878797	1.11
1982	10365500	-0.82	3212242	0.86	13577742	-0.44
1989	9353141	-1.46	3128256	-0.38	12481397	-1.20
1994	9096121	-0.56	2931177	-1.29	12027298	-0.74
1997	9046538	-0.18	2741236	-2.21	11787774	-0.67
2004	9141043	0.15	1658415	-6.93	10799458	-1.24
2007	11188709	6.97	2009002	6.60	13197711	6.91

Source: Integrated Sample Survey Reports (Various years), Government of Tamil Nadu.

Table 2. Compositional structure of bovine population in Tamil Nadu during last decade (1997–2007)

Particulars	1997		2007	
	Total in numbers	%	Total in numbers	%
Cattle				
Milch animal	4001868	42.74	4775280	42.68
Draught animal	1942186	20.74	1171330	10.47
Young stock	3076565	32.86	4598862	41.10
Others	342018	3.65	643237	5.75
Total	9362637	100.00	11188709	100.00
Buffalo				
Milch animal	1360384	49.63	899865	44.79
Draught animal	139641	5.09	106221	5.29
Young stock	1172252	42.76	858174	42.72
Others	68986	2.52	144742	7.20
Total	2741263	100.00	2009002	100.00

Source: Livestock Census (2007), Directorate of Veterinary services Government of Tamil Nadu.

population in Tamil Nadu over different census periods is presented in Table 1. The cattle population in India stood at 11.19 millions in 2007, which had increased from 10.22 millions in 1951. The cattle population showed a negative growth trend during various census periods in the past, except during 1956–1961, 1961–1966, 1974–1977, 1997–2004 and 2004–2007 inter-census periods. However, in case of buffaloes, the population growth trend was positive for all the census periods except during 1951–1956 and 1982 and 2004. Buffaloes in Tamil Nadu were estimated to be 2.30 millions in 1951 and it has reduced to 2.01 millions in 2007. As a whole, the positive trend of total bovine population was observed during the inter-census periods, viz. 1956–1961, 1961–1966, 1974–1977 and 2004–2007.

*Compositional change in bovine population of Tamil Nadu during last decade (1997–2007):* Over the last 10 years (1997–2007), major structural changes were witnessed in the composition of livestock population of the State (Table 2). During 1997, 43% of total cattle were milch animals and draught cattle formed 21%, young stock 33%

Table 3. Breed-wise composition of cattle and buffalo population in Tamil Nadu (2007)

S.No.	Cattle/buffalo breeds	Population in numbers	% to respective total
Indigenous cattle breeds			
1	Alambadi	31874	0.84
2	Bargur	20879	0.55
3	Jellicut	34191	0.90
4	Kangayam	314817	8.27
5	Manapuri	102046	2.68
6	Umbalacherry	217193	5.71
7	Other's graded	266331	7.00
8	Non-descript	2818700	74.06
	Total indigenous cattle	3806031	100.00
Exotic cattle			
1	Jersey	236030	69.59
2	Holstein Friesien	45541	13.43
3	Other exotic	57604	16.98
	Total exotic cattle	339175	100.00
Crossbred cattle			
1	Jersey cross	5280682	74.97
2	Holstein Friesien cross	1497959	21.27
3	Other crossbred	264862	3.76
	Total crossbred cattle	7043503	100.00
Buffalo			
1	Murrah	246601	12.27
2	Toda	50404	2.51
3	Others Graded	474201	23.60
	Non-descript	1237796	61.61
	Total buffaloes	2009002	100.00

Source: Livestock Census (2007), Directorate of Veterinary services Government of Tamil Nadu.

and other animals 3% of the total cattle population. But in 2007, only 10% of total cattle were draught animals. The milch cattle remained same 43% of the total cattle population similar to 1997. The young stock and other animals formed nearly 41 and 6%, respectively. The compositional structure of buffalo population in Tamil Nadu was different from that of cattle. In 1997, one-half of the

total buffalo population were found to be of milch buffalo which has reduced to 45% in 2007. Only negligible proportion of total population (5%) were used for draught purposes during both the periods. There was no change in the proportion of young stock buffaloes between the periods 1997 and 2007 and were worked out to be 43% of the total buffalo population of the State.

The reduction in draught animal proportion might be due to the reasons viz., Urbanization and farm mechanization, indiscriminate crossbreeding, less efficient harnesses, poor feeding, housing, health and other management practices of draught animals, inefficient conversion of draught efforts due to poor design of implements and improper management of draught animal power.

**Breed-wise composition of cattle and buffaloes in Tamil Nadu (2007):** The breed-wise composition of cattle and buffalo population in Tamil Nadu in 2007 (Table 3) revealed that the crossbred and indigenous cattle contributed major proportion to the total bovine population in Tamil Nadu in 2007.

Among various indigenous cattle breeds, non-descript cattle formed about three-fourth of the indigenous cattle, followed by Kangayam (8%), other graded cattle (7%), Umbalacherry (6%), Manapuri (3%), Jellicut (1%), Alambadi (1%) and Bargur (0.5%). Of the total exotic cattle of Tamil Nadu in 2007, about 70% comprised Jersey breed. Holstein-Friesian breed accounted for about 13% of the total exotic cattle. Three-fourths of the total crossbred cattle

population was constituted by Jersey cross and about one-fifth by Holstein Friesian crossbreds. Among the total buffalo population of 2 millions in 2007, 61.61% was constituted by non-descript, followed by graded buffalo (23.60%), Murrah (12.27%) and Toda buffaloes (2.51%).

About 15 draught cattle breeds were observed in Tamil Nadu. Among them, Kangayam, Umbalacherry, Bargur and Pulikulam or Jellicat were the most popular draught breeds in Tamil Nadu. Vivekanandan and Alagumani (2013) reported that population of Pulikulam draught cattle declined from 90,000 in 1995 to 21,225 in 2012. They further estimated that Bargur draught cattle declined from 1 lakh in 1991 to 10,560 in 2012.

**Temporal analysis of work animal population in Tamil Nadu (1956 to 2007):** The work animal population in Tamil Nadu from 1956 to 2007 (Fig. 1) increased slightly for 1956 to 1961 and thereafter, it was continuously decreasing till 2004. For the last inter-census period 2004–2007, the work animal population had increased from 1.13 million to 1.28 millions. The reasons for the drastic decline in work animal population in Tamil Nadu might be due to increased urbanization, increased mechanization, decrease in net sown area, decrease in cultivators, psychological changes in attitude of work animal owners, etc. The annual compound growth rate of work animal population in Tamil Nadu over the years (Fig. 2) revealed that ACGR was negative for all the census periods except for the period 1956–61 and 2004–07. The trends in work animal population, its composition and density in Tamil Nadu was worked out for 1956 to 1997 by Dhas (2008) and for the 2004 and 2007, the above parameters were worked out and the results are presented in Table 4.

**Share of work animal population to total bovines in Tamil Nadu (1956 to 2007):** The share of work animal population to the total bovine population is shown in Table 4 and depicted in Fig. 3. The share of draught animal continuously decreased from about one-half in 1956 to about one-third in 1982, one-fourth in 1994 and to about one-tenth during 2004 and 2007. This scenario was clearly illustrated with the use of area diagram as shown in the Fig. 4. The reasons

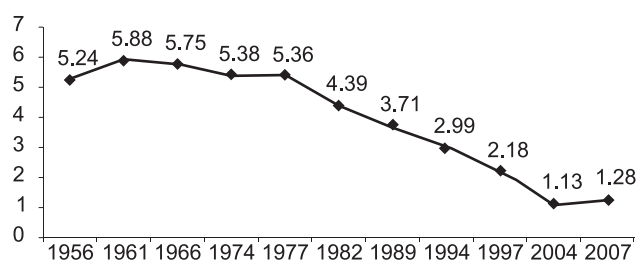


Fig. 1. Growth trend in work animal population in Tamil Nadu (in million numbers for the period 1956 to 2007).

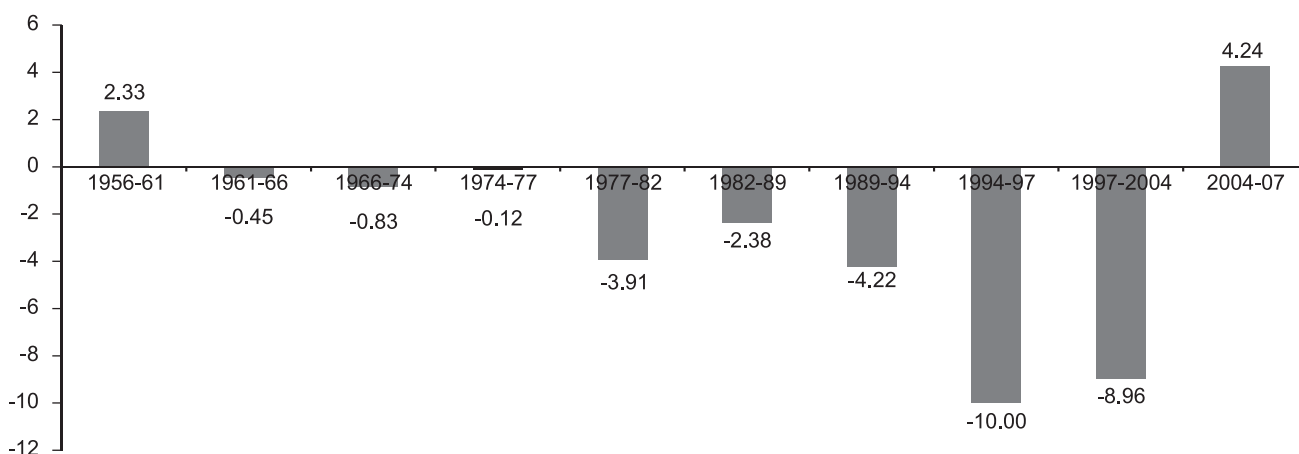


Fig. 2. Annual compound growth rate of work animal population in Tamil Nadu over different census periods (in %).

Table 4. Trends in work animal population, its composition and density in Tamil Nadu (1956 to 2007)

Particulars	1956	1961	1966	1974	1977	1982	1989	1994	1997	2004	2007
Total work animals (in million numbers)	5.24	5.88	5.75	5.38	5.36	4.39	3.71	2.99	2.18	1.13	1.28
Total animal power (in lakh HP)	20.96	23.50	23.00	21.51	21.45	17.54	14.85	11.94	8.72	4.52	5.12
Annual compound growth rate (%)	-	2.33	-0.45	-0.83	-0.12	-3.91	-2.38	-4.22	-10.00	-8.96	4.24
Share to the total bovines (%)	44.64	43.78	42.33	40.06	38.63	32.30	29.76	24.82	18.51	10.46	9.70
Density of work animal population											
Animals per hectare of gross cropped area (in numbers)	0.76	0.81	0.80	0.75	0.71	0.66	0.56	0.44	0.33	0.18	0.22

Total farm power includes the energy supplied by mechanical and electrical equipments and animals. It is assumed that tractors supply about 25 horse power (HP) each, pump sets and oil engines about 5 HP each and work animals about 0.4 HP each per day.

Source: Dhas (2008); Livestock Census 2004 and 2007.

for the decline in the share of work animals to total bovine population might be due to labour shortage and increase in milch animal population due to operation flood / intensive crossbreeding programme. Due to increase in the milch animal population, there might be drastic reduction in work animal population, which was also supported by a decrease in landholdings and cultivator population, fragmentation of cultivable land, farm mechanization, reduction in grazing land, urbanization, etc.

*Scenario of draught animal population (DAP) density in Tamil Nadu (1956 to 2007):* The DAP density in Tamil Nadu was calculated for various livestock census periods (Fig. 4). The DAP density was 0.76 in 1956, which had then increased to 0.81 in 1961 and later on decreased continuously to 0.18 in 2004 and finally, it improved slightly

to 0.22. Based on the DAP density, a trend line was fitted and shown in Fig. 4. In spite of decreasing trend in gross cropped area in Tamil Nadu over the years, DAP density also had a decreasing trend. The trend equation for the draught animal population density over years was fitted as  $y = 26.01 - 0.012x$ . This clearly evinced the severity of decline in the draught animal population. Thus it is inferred that the decrease in draught animals was more severe than the decline in gross cropped area in Tamil Nadu over the years.

*Availability of animal power in Tamil Nadu (1956 to 2007):* As shown in Table 4 and Fig. 5, the total animal power of 20.96 lakh HP was available in Tamil Nadu during 1956 and it had drastically reduced to 8.72 HP in 1997 and further reduced to 5.12 lakh HP in 2007.

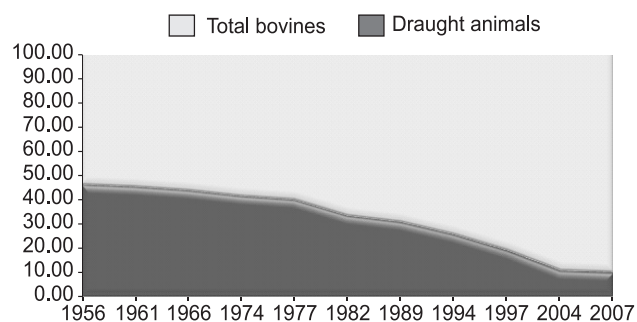


Fig. 3. Share of work animal to total bovine population in Tamil Nadu (in % from 1956 to 2007).

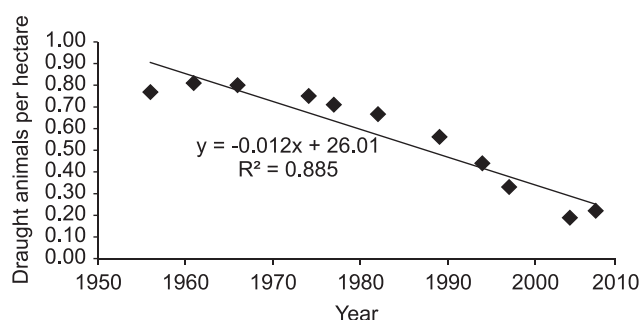


Fig. 4. Trend in draught animal population density in Tamil Nadu (in numbers/ha of gross cropped area).

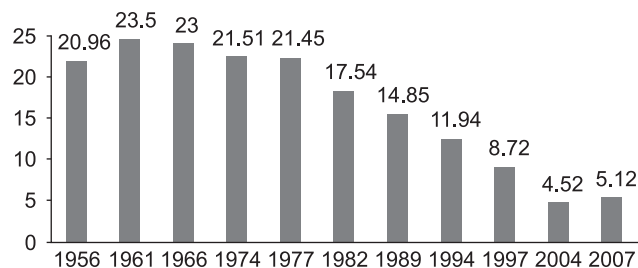


Fig. 5. Growth trend in availability of animal power in Tamil Nadu (in lakh HP for the period 1956 to 2007).

*Spatial and temporal variations in population of draught cattle and buffaloes in Tamil Nadu:* The district-wise variations in draught cattle and buffalo population in Tamil Nadu are presented in Table 5. The exotic/ crossbred draught cattle in Tamil Nadu were 1.65 lakh in 2004, which had increased to 4.33 lakh with the annual compound growth rate (ACGR) of 37.88%. The drastic increase in exotic / crossbred draught cattle population was observed in Thoothukudi (183.61%), Thiruvallur (106.51%) and Namakkal (101.35%) districts. Further, Cuddalore, Erode, Perambalur+Ariyalur, Ramnad and Salem districts were found to have the annual compound growth rate between 50.21% to 86.71%. In contrast, negative ACGR for exotic/ crossbred draught cattle population was observed in Chennai, Dindigul, Kanyakumari, Karur, Sivagangai, Theni

and Thanjavur districts for the period from 2004 to 2007.

Population of draught cattle of indigenous breeds was 7.39 lakh in Tamil Nadu in 2007, which had decreased from 9.31 lakh in 2004 with the negative ACGR of -7.43%. All the districts were found to have negative ACGR from 2004 to 2007 for indigenous draught cattle population in Tamil Nadu except for the districts, Thoothukudi (38.04%), Tiruchirappalli (18.15%), Pudukottai (12.93%), Virudhunagar (10.39%), Madurai (7.65%), Kanyakumari (1.84%) and Theni (1.60%). The negative decline in indigenous draught cattle population was severe in Ramnad, Chennai, Cuddalore, Namakkal, Dharmapuri+

Krishnagiri, Dindigul, Sivagangai, Thiruvallur, The Nilgiris, Villupuram, Coimbatore and Salem districts with ACGR of -10.71 to -58.45%.

The draught buffaloes in Tamil Nadu increased from 0.31 lakh in 2004 to 1.06 lakh in 2007 with ACGR of 51.38% (Table 5). More than 100% ACGR was observed among the districts, viz. Namakkal, Salem, Thoothukudi, Thiruvallur and Erode districts. The districts namely Coimbatore, Perambalur+Ariyalur, Tiruchirappalli, Tirunelveli, Vellore, Pudukottai, Dharmapuri+ Krishnagiri were found to have ACGR of 37.66% to 58.92% for the draught buffalo growth from 2004 to 2007. The negative

Table 5. Spatial and temporal variations in population of draught cattle and buffaloes in Tamil Nadu (2004 to 2007)

S.No.	Districts	Exotic/ crossbred draught cattle			Indigenous draught cattle			Draught buffalo			Total draught cattle and buffalo		
		2007	2004	ACGR%	2007	2004	ACGR%	2007	2004	ACGR%	2007	2004	ACGR%
1	Chennai	31	132	-38.30	66	498	-49.02	88	240	-28.43	185	870	-40.31
2	Coimbatore	18797	8027	32.79	10422	15628	-12.63	899	224	58.92	30118	23879	8.04
3	Cuddalore	28522	4382	86.71	9200	33424	-34.95	1607	990	17.52	39329	38796	0.46
4	Dharmapuri+ Krishnagiri	10957	3781	42.57	29647	66994	-23.80	2113	810	37.66	42717	71585	-15.81
5	Dindigul	2432	3461	-11.10	10313	20888	-20.96	454	503	-3.36	13199	24852	-19.02
6	Erode	16564	3719	64.53	24013	29320	-6.44	11333	1200	111.38	51910	34239	14.88
7	Kancheepuram	14618	5682	37.02	55518	63902	-4.58	6469	4019	17.19	76605	73603	1.34
8	Kanyakumari	503	1184	-24.83	1032	977	1.84	208	588	-29.28	1743	2749	-14.09
9	Karur	468	1561	-33.07	6282	7097	-3.98	275	811	-30.27	7025	9469	-9.47
10	Madurai	2793	3244	-4.87	15901	12748	7.65	52	216	-37.79	18746	16208	4.97
11	Nagapattinam	5456	3506	15.88	14274	16437	-4.59	385	711	-18.49	20115	20654	-0.88
12	Namakkal	7567	927	101.35	4404	12845	-30.01	7276	381	167.29	19247	14153	10.79
13	Perambalur+ Ariyalur	13946	3916	52.71	27496	28774	-1.50	880	224	57.79	42322	32914	8.74
14	Pudukottai	18186	8592	28.39	85037	59051	12.93	5531	1848	44.11	108754	69491	16.10
15	Ramnad	11340	3346	50.21	844	11769	-58.45	125	246	-20.20	12309	15361	-7.12
16	Salem	14700	3478	61.68	25207	35406	-10.71	8154	649	132.47	48061	39533	6.73
17	Sivagangai	1820	4981	-28.51	22877	39058	-16.33	120	455	-35.87	24817	44494	-17.68
18	Thanjavur	12464	15238	-6.48	43449	51426	-5.46	619	986	-14.37	56532	67650	-5.81
19	The Nilgiris	986	308	47.38	324	514	-14.26	58	215	-35.39	1368	1037	9.67
20	Theni	868	1730	-20.54	5849	5577	1.60	105	805	-49.29	6822	8112	-5.61
21	Thiruvallur	39060	4435	106.51	19323	32566	-15.97	34702	3558	113.66	93085	40559	31.91
22	Thiruvannamalai	26265	17902	13.63	69155	92973	-9.39	1339	1876	-10.63	96759	112751	-4.97
23	Thiruvallur	5624	3778	14.18	18382	23833	-8.29	128	318	-26.17	24134	27929	-4.75
24	Thoothukudi	69759	3058	183.61	30843	11727	38.04	5192	498	118.46	105794	15283	90.58
25	Tirunelveli	29787	8986	49.10	16263	19139	-5.28	9345	3007	45.93	55395	31132	21.18
26	Thiruchirappalli	8741	6776	8.86	25531	15478	18.15	1593	472	50.00	35865	22726	16.43
27	Vellore	19825	12615	16.26	54334	63970	-5.30	2299	740	45.92	76458	77325	-0.38
28	Villupuram	44580	20592	29.36	96534	147108	-13.10	2792	2687	1.29	143906	170387	-5.47
29	Virudhunagar	5952	5712	1.38	16199	12041	10.39	2080	1346	15.61	24231	19099	8.26
	STATE	432611	165049	37.88	738719	931168	-7.43	106221	30623	51.38	1277551	1126840	4.27

Source : Livestock Census (2004 and 2007), Directorate of Veterinary services Government of Tamil Nadu.



ACGR for the draught buffalo population in Tamil Nadu was observed with the intensity of – 49.29% to –10.63% among Theni, Madurai, Sivagangai, Nilgiris, Karur, Kanyakumari, Chennai, Thiruvallur, Ramnad, agapattinam, Thanjavur and Thiruvannamalai districts.

As a whole, the total draught cattle and buffalo population in Tamil Nadu was 1.27 lakh in 2007, which increased from 1.13 lakh in 2004, with ACGR of 4.27%. About 10 to 90% growth rate was observed among Namakkal, Erode, Pudukottai, Tiruchirappalli, Tirunelveli, Thiruvallur and Thoothukudi districts. In contrast, Chennai, Dindigul, Sivagangai, Dharmapuri+Krishnagiri, Kanyakumari and Karur districts had negative ACGR with the values ranging between –40.31% and –9.47% for the period between 2004 and 2007. The increase in draught cattle and buffalo population during last two census periods might be due to effective implementation of crossbreeding development and buffalo development programmes during the mentioned periods.

Improved use of draught animals power source for agricultural production is the most appropriate and relevant form of strategy for smallholder agriculture due to economical, technical and agro-ecological problems associated with mechanized agriculture (Chanie *et al.* 2012). Use of animal power generally enables farmers in Tamil Nadu as well India to increase agricultural production and hence, contributes a lot towards ensuring food and economic security in the country. As a whole, the draught cattle and buffalo population in Tamil Nadu was decreasing over years and hence some of the strategies for improvement of draught animal power are discussed here.

- Strategies should be framed to improve draught animal power supply, which include improvements in care and management like nutrition / feeding, healthcare, harnessing techniques and conserving genetic quality. Better management practices need to be followed right from selecting the draught animal based on their economic traits and breeding them to improve genetic potential.
- Suitable strategies for optimum utilization and for maximizing the performance of draught animals for agricultural operations are recommended.
- Regular and reliable record of draught cattle population has to be carried out.
- The absence of studies to improve the traits for work performance of draught cattle indicates the least emphasis was given so far in promoting draught

animal power. Hence, constant and continuous focus should be made on draught animal research.

- Access to credit from financial institutions and sustainable market for the animals are to be improved. Steps are to be initiated for proper valuation of draught animals and to reduce exploitation by middlemen.
- Improvement in grazing land and wasteland by way of fodder production is required for economic management of draught animals.

## REFERENCES

- Akila N and Chander M. 2009. Farmers' attitude towards utilization of draught bullocks in Indian agriculture. *Livestock Research for Rural Development* **21**(5). [www.lrrd.org/lrrd21/5/akil21076.htm](http://www.lrrd.org/lrrd21/5/akil21076.htm) Part of Ph.D. thesis submitted to Indian Veterinary Research Institute, Izatnagar.
- Chanie M, Fentahun T, Mitiku T and Berhan M. 2012. Strategies for improvement of draft animal power supply for cultivation in Ethiopia: A review. *European Journal of Biological Sciences* **4** (3): 96–104.
- Dhas A C. 2008. Determinants of work animal density in Tamil Nadu: an econometric analysis. *Munich Personal RePEc archive paper number 9589*. <http://mpra.ub.uni-muenchen.de/9589/>
- Dikshit A K and Bithal P S. 2010. Environmental value of draught animals: saving of fossil-fuel and prevention of greenhouse gas emission. *Agricultural Economics Research Review* **23**: 227–32.
- Sastry N S R and Thomas C K. 2005. *Livestock Production Management*. 4<sup>th</sup> edn, p.449. Kalyani Publishers.
- Shisode M G, Bhokre S M, Kulkarni M D and Khanvilkar A V. 2010. Draft animal power – our nation's wealth. *SMVS' dairy year book*. pp. 31–32.
- Singh J. 2008. Scope, progress and constraints of farm mechanization in India. Status of farm mechanization in India. <http://agricoop.nic.in/Farm%20Mech.%20PDF/contents.htm>.
- Vivekanandan P and Alagumani V. 2013. Community conservation of local livestock breeds. *NABARD Supported Project Report towards Capacity Building of Livestock Keepers for Conserving 10 Local Breeds in Tamil Nadu*. Sustainable-agriculture and Environmental Voluntary Action (SEVA), Madurai–625 010.
- Meganathan N, Pandian A S S, Selvakumar K N and Prabakaran R. 2004. Structural and Compositional changes in Small Ruminants population of Tamil Nadu. *Indian Journal of Small Ruminants* **10**(2): 166–168.
- Selvakumar K N. 1996. 'Growth dimensions of livestock sector in Tamil Nadu: An econometric analysis.' Unpublished Ph.D. thesis submitted to the University of Agricultural Sciences, Bengaluru.