Determinants of Work Animal Density in Tamil Nadu: An Econometric Analysis

Dhas, Albert Christopher
The American College, Madurai

10. August 2008

Determinants of Work Animal Density in Tamil Nadu: An Econometric Analysis

R.Albert Christopher Dhas
Senior Lecturer in Economics
The American College
Madurai-2.

[Note: This paper is submitted for presentation in the 41st Annual Conference of the Indian Econometric Society, held at Jadavpur University, Kolkata from 20th to 22nd January, 2005. The author acknowledges Dr.K.N.Nair, Fellow, Centre for Development Studies, Trivandrum for his guidance and comments on this paper.]

Determinants of Work Animal Density in Tamil Nadu: An Econometric Analysis

R.Albert Christopher Dhas
Senior Lecturer in Economics
The American College
Madurai-2.

Bovines, both work and milch stock, recorded a steady growth during the pre-independence period in Tamil Nadu. And, from independence, size and composition of bovines showed differential growth pattern (Dhas:1986). The total bovine population showed an increasing trend up to the early-Sixties and thereafter stagnant till the early Eighties. While the milch animal stock increased steadily, the work animals showed a declining trend from seventies. These trends not only indicate the growing importance of dairy animals but also the competitive linkage between work and milch animal population. The work animal stock is highly influenced by the agro-climatic, institutional and economic factors and an analysis of capturing them is attempted in this paper.

The discussion in this paper is sequenced as below: Initially, the changes in the size and composition of bovines, work animal population and its density since independence are traced. Subsequently, the factors determining work animal population and its density are examined using regression models.

Trends in Work Animal Population and Its Density in Tamil Nadu

The total number of bovines in 1956 was 11.74 million (Table 1). By early sixties, the total stock had increased to 13 million and remained unchanged up to early eighties. The total number of bovines in 1982 was 13.58 million. Thereafter, there was a steady fall in the bovine population and became 11.97 million by 1997, which was almost equal to that of 1956. Thus, the total bovine population showed an increasing trend up to the early-Sixties: stagnation up to the early Eighties; and a declining trend thereafter.

Table 1
Trends in the Size and Composition of Bovine Population in Tamil Nadu (1956-1997)

Year	CATTLE					BUFFALO					TOTAL BOVINE STOCK
	Male		Female		Total Cattle	Male		Female		Total Buffalo	
	adult	young-stock	adult	young-Stock		adult	young-Stock	adult	young-stock		
1956	4.2	1.17	3.45	1.01	9.70 [82.62]	0.28	0.44	1.06	0.69	2.04 [17.38]	11.74 [100]
	(46.18)	(11.19)	(32.98)	(9.65)	(100)	(15.77)	(16.92)	(40.77)	(26.54)	(100)	
1961	5.08	1.06	3.65	1.04	10.83 [80.70]	0.46	0.41	1.29	0.43	2.59 [19.30]	13.42 [100]
	(46.91)	(9.79)	(33.70)	(9.60)	(100)	(17.76)	(15.83)	(49.81)	(16.60)	(100)	
1966	4.95	1.10	3.71	1.10	10.86 [79.97]	0.50	0.38	1.35	0.49	2.72 [20.03]	13.58 [100]
	(45.58)	(10.13)	(34.16)	(10.13)	(100)	(18.38)	(13.97)	(49.63)	(18.02)	(100)	
1974	4.64	1.10	3.66	1.17	10.57 [78.76]	0.40	0.41	1.48	0.56	2.85 [21.24]	13.42 [100]
	(43.9)	(10.40)	(34.63)	(11.07)	(100)	(14.04)	(14.38)	(51.93)	(19.65)	(100)	
1977	4.64	1.13	3.80	1.23	10.80 [77.81]	0.38	0.43	1.64	0.63	3.08 [22.19]	13.88 [100]
	(42.96)	(10.46)	(35.19)	(11.39)	(100)	(12.34)	(13.96)	(53.25)	(20.45)	(100)	
1982	3.94	1.26	3.49	1.68	10.37 [76.36]	0.30	0.37	1.72	0.82	3.21 [23.64]	13.58 [100]
	(37.99)	(12.15)	(33.66)	(16.20)	(100)	(9.35)	(11.53)	(53.58)	(25.54)	(100)	
1989	3.30	1.01	3.30	1.74	9.35 [74.94]	0.21	0.29	1.67	0.96	3.13 [25.06]	12.48 [100]
	(35.25)	(10.79)	(35.33)	(18.63)	(100)	(6.64)	(9.33)	(53.49)	(30.54)	(100)	
1994	2.76	0.97	3.36	2.01	9.10 [75.64]	0.19	0.31	1.56	0.87	2.93 [24.36]	12.03 [100]
	(30.33)	(10.66)	(36.92)	(22.09)	(100)	(6.49)	(10.58)	(53.24)	(29.69)	(100)	
1997	2.25	1.13	3.53	2.14	9.05 [76.76]	0.18	0.33	1.39	0.85	2.74 [23.24]	11.79 [100]
	(24.83)	(12.49)	(39.01)	(23.66)	(100)	(6.58)	(11.89)	(57.24)	(30.87)	(100)	

Source: Livestock Census, various years.

An analysis of the trends in the species composition indicates that the share of cattle to the total bovines has been declining steadily till late eighties and thereafter marginally increased. During the mid fifties, cattle accounted for about 83 per cent of the bovine stock. In 1989, the share of cattle was 75 per cent. Thereafter, it has increased to 77 per cent by 1997.

During the early Fifties, about 47 per cent of the bovines were male stock and the rest females. The sharp decline in the share of male stock and the concurrent increase in the females in the total bovine population indicates that the importance of female bovines has been increasing in the State. The shift in the bovine composition in favour of female stock is observed in both the cattle and buffalo species.

The shifts in the relative importance of work and milch animals indicate the adjustments carried out by the farmers in managing their herd size and composition in accordance with the changing scenario.

The trends in work animal population and its density in Tamil Nadu is presented in Table 2. According to the 1956 Livestock Census, the total stock of draught animals in Tamil Nadu was about 5.24 million and it increased to 5.88 million by the early Sixties. In the subsequent years, while it had shown a declining trend[1], the decline became very sharp in Eighties. According to the latest livestock census, the total draught animal population in the State during 1997 was only 2.18 million. The annual growth rate estimates reveal that while a negative growth rate of less

---

1 The declining trend in the work animal population in Tamil Nadu from the early Sixties has been highlighted in the earlier studies by A.Vaidyanathan(1978), Mishra and Sharma (1989), Dhas (1986), Nair and Dhas(1990). These studies had used the data up to the early Eighties or prior to that only.

than one was observed during Sixties and Seventies, it was between 2 to 9 percentages during Eighties and Nineties. The share of work animals to the total bovines and total adult bovines had shown a steady decline during the reference period.

The density of work animals per hectare of gross cropped area was 0.76 in the mid Fifties, which increased to 0.81 and remained unchanged till mid Sixties, while a declining trend was observed thereafter. The decline in the density has been very sharp and significant from mid-seventies onwards.

Table 2
Trends in Work Animal Population, its Composition and Density in Tamil Nadu

Particulars		1956	1961	1966	1974	1977	1982	1989	1994	1997
Size of Work Animal Population										
Total Work Animals (in million Nos.)		5.24	5.88	5.75	5.38	5.36	4.39	3.71	2.99	2.18
Total Animal Power (in lakh HP)		20.96	23.50	23.00	21.51	21.45	17.54	14.85	11.94	8.72
Annual growth rate (%)		-	2.43	-0.43	-0.81	-0.10	-3.64	-2.21	-3.89	-8.97
Share to the total Bovines (%)		44.64	43.78	42.33	40.06	38.63	32.30	29.76	24.82	18.51
Share to the total adult Bovine(%)		58.17	56.07	54.73	52.80	51.25	46.39	43.70	37.95	29.71
Density of Work Animal Population										
Animals per Gross Cropped Area		0.76	0.81	0.80	0.75	0.71	0.66	0.56	0.44	0.33
Composition of Farm Power (%)										
By Source	Animal Power	87.88	76.77	63.04	31.14	27.99	22.13	19.06	15.11	9.14
	Mechanical Power	12.12	23.23	36.76	68.86	72.01	77.87	80.94	84.89	90.86
	Total Farm Power	100	100	100	100	100	100	100	100	100

Note: 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, pumpsets and oil engines about 5 HP each and work animals about 0.4 HP each per day.
N.A = Not Available.

Source: 1. Livestock Census Reports, Chennai, various issues
2. Season and Crop Reports of Tamilnadu, Chennai, various issues

The work animal population and its density is influenced by a number of factors such as, land use, irrigation, climate, landholding, agriculture and technological factors. The contributions of these factors are both direct and indirect. More over, the relative contributions made by these factors do vary over time. We shall examine the relationship between these variables and their influence on the trends in the work animal population in Tamil Nadu since independence.

Factors Determining Trends in Work Animal Population

The relationship between the work animal population and the land use pattern needs to be established from both demand and supply side. On the demand side, the total cultivated area is an important factor that determines the requirement of work animals. If the scope for the agricultural expansion were high one would expect the demand for animals would also be at a higher level. From supply point of view, to sustain the work animal stock the feed supply is very important and the principal and by-products from the cultivated area are directly meeting that. As such, there could be a positive association between density of work animals and extent of cultivation. The requirement of farm power is likely to be high in those regions where cultivated area or the scope for agricultural expansion[2] is also high and vice-versa.

In this context, it is important to relate the density of work animals and cropping intensity. If the cultivated area is intensively used, one would expect the total farm power requirement to be high and that would lead to an increase in the work animal density. If the cropping intensity facilitates

2 The land use pattern has been undergoing significant change in Tamil Nadu since independence. On the whole, the trends in the land use pattern revealed that the state had recorded an upward trend in agricultural expansion up to the mid-Seventies and thereafter, a declining trend.

in the intensive use of work animals (by using the animals more hours efficiently), it may not increase the density of work animals, even though the total farm power requirement increases.

More over, the land use pattern, agricultural expansion and the cropping intensity are highly influenced by the agro-climatic conditions and irrigation patterns. In fact, both the agro-climatic and irrigation conditions are directly related to the work animal stock. The agro-climatic conditions, particularly the seasonal pattern of rainfall has significant influence on the work animal population and its use pattern. The agricultural operations in rain-fed areas are heavily dependent on the quantum of rainfall and its seasonal concentration. In general, summer is generally hot and the soil becomes so dry and hard. Hence, on the set of monsoon3 by June, the land is to be ploughed and made ready for cultivation within a short span of time so that farmers can take advantage of the rains for sowing. In this context, the use of animals provides enough strength and flexibility for the cultivators and thereby serves as 'energy gate'.

Irrigation, in general, has a positive association with the work animal population and its influence is both direct and indirect. When irrigation is better and large, the cultivation will be significant which would increase the draught power requirement for agriculture. The percentage share of irrigated area to the total cultivated area could measure the irrigation performance4.

3 Though both the monsoon periods, South-West and North-East, are important sources of rainfall in Tamil Nadu, the monsoon just after the hot summer assumes importance as far as cultivation is concerned. It can be seen that these two monsoons together accounted for more than 82 per cent of the total rainfall in the state.

4 Irrigation plays a significant role in the Tamil Nadu agriculture. While an increase in both net and gross irrigated areas is observed during the period under reference, a mild fall is observed in the trend during the late Seventies and Eighties. The growing importance of irrigation in Tamil Nadu's agriculture is reflected in the growth rates of the NIA and GIA. A closer look at the sources of irrigation revealed that canals, tanks and wells are the three major sources, which contributes for about 99 per cent of the NIA. Of these sources, the relative importance of wells had increased significantly; the importance of tanks

Among the different sources of irrigation, the influence of well irrigation is not only significant and important, but also different from other sources. As well irrigation means assured water supply for cultivation and assured demand for draught power, in regions where well irrigation is high the work animal population would also be high. In addition, as animals are directly employed for lifting water from wells, well irrigation has a direct influence on the density of work animal population. However, if water was lifted by power (pumpsets and oil engines), it would mean that mechanisation of irrigation would displace the animals used for irrigation purposes and thereby reduce the work animal stock. In fact, mechanisation of irrigation5 has differential impact on the work animal population. Electric pumpsets and oil engines can displace animals employed for lift irrigation. Energisation of wells may also lead to an increase in the volume of water lifted per unit of time, which may result in an extension of cultivated area and rise in cropping intensity. Consequently, the requirement of draught power may increase for other operations like tillage, manuring, harvesting, threshing, etc., From above, it is clear that the relationship between work animal population and irrigation pattern is complex: the level of irrigation, sources of irrigation, extent of mechanisation of irrigation and other farm activities condition it.

---

declined drastically and that of canals remained unchanged up to early Eighties and thereafter declined marginally.

5 The growth of mechanization of irrigation had contributed significantly to the increase in the availability of draught power in agriculture. With the rapid increase in the number of pumpsets and oil engines, its availability per hectare of gross cropped area has also increased significantly.

Trends in Pumpsets and Oil Engines in Tamil Nadu (1956-1997)

Particulars	1956	1961	1966	1974	1977	1982	1989	1994	1997
Number of Pumpsets & Oil Engines (in 000)	53.73	60.80	251.34	915.62	821.51	1150.79	1128.10	1146.61	1185.75
Share of Electrical Power to the Total Farm Power	11.26	11.35	34.45	66.28	63.53	72.58	72.50	72.56	62.15
Number of Pumpsets per 1000 hect. of GCA	8	8	35	125	111	178	169	162	181

Source: Livestock Census Reports, various years.

If mechanization of irrigation is followed by mechanization of land preparation and other cultivation operations like harvesting, threshing etc., it would result in reduction in work animal stock. In this context, it is useful to highlight the influence of cultivation pattern on work animal population. The cultivation pattern refers to the combination of various activities that are undertaken in cultivating agricultural crops. These activities could be broadly classified under (i) land preparation activities6, (ii) sowing and/or crop planting activities7, (iii) plant protection activities8, (iv) harvesting or reaping activities9 and (v) post- harvesting activities10. Generally, the cultivation pattern (cultivation activities) varies significantly across crops, regions, agro-climatic conditions, size class of farms and socio-economic background of the cultivators. However, in a particular region for a specific crop, the cultivation pattern remains almost unchanged. More over, the cultivation pattern between food crops and non-food crops vary significantly. For instance, non-food crops like ground nut, gingelly etc., do show similar cultivation pattern as in case of certain food grains. Within the food crops, the cultivation pattern of foodgrains (cereals and pulses) are similar and it varies very much as compared to that of the other food crops such as condiments and spices, sugar crops, and fruits and vegetables including root crops. Whatever may be the cultivation pattern followed, the use of agricultural implements operated either by human or animal or electric power or tractor is imperative. According to the cultivation pattern adopted and the availability of farm power, the required agricultural

---

6 Land preparation activities include, ploughing, levelling, bedding and manuring.

7 Planting activities include sowing/planting of seeds or planting of cuttings and growing and transplanting nurseries.

8 Plant protection activities include control of weeds, application of manures, irrigation and application of pesticides.

9 Harvesting includes separation of the output from the crop either by cutting, plucking or stripping.

implements are opted. While a few operations could be carried out either by human or electricity, most of the activities could be done either by animal or tractor. In fact, mechanical equipments could perform most of the activities that are carried out by humans and animals.

Though the relationship between the use of work animals and mechanical equipments seems to be simple and associated negatively, in reality their relationship is complex and requires an in-depth exploration. For instance, tractors can displace draught animals in land preparation, sowing, manuring and threshing. But, the influence of tractors in reducing the work animal population is constrained by the scale operation and fragmentation of land holdings. For a tractor to be economical its scale of operation should be high and therefore, tractorisation is generally carried out in large farms. More over, due to fragmentation of land holdings, the average size of landholding declines and the number of plots per household also increases which raise constraints on tractorisation and consequent displacement of work animals, particularly at the small and marginal farms. To understand this phenomenon, it is necessary to analyse the major institutional changes, i.e., land holding pattern and the size of land holdings over time

The relationship between size of land holding and work animal population flows out of the density-dependent hypothesis formulated by Vaidyanathan, Nair and Harris (1982). As per the hypothesis, there are two phases: (a) initial phase - decline in size of landholding but increase in density of work animals and (b) final phase- decline in both the size of landholding and density of work animals, and the turn in these phases begins when the size of land holding reaches a critical minimum size.

---

10 Post harvest activities include threshing, separation of shells, crushing and transportation.

The agro-climatic, institutional and economic forces influence the farmers' decision on their cropping pattern, which in fact determines the work animal requirement also. The cropping pattern may be seen as 'Food vs. Non-food crops', from the view point of 'use'; as commercial vs. non-commercial, from the view of 'market value'; as 'short vs. long duration crops', from crop life point of view; as 'irrigated vs. unirrigated/ rain fed' from the angle of 'irrigation type' adopted; etc.,. From the point of input use, particularly animal labour input, the cropping pattern is to be examined as 'High vs. low/nil animal labour input use crops'.

We have discussed the various factors that have an influence on the work animal population and its density. In order to explain the influence of agro-climatic, economic and institutional and technological factors on the work animal density, Dr.A.Vaidyanathan (1988) used a multiple regression model. Recently, Rakesh Saxena (1995) examined the relationship between density of work animals with the density of tractors, average size of land holdings and percentage of dug well irrigated area in net irrigated area of Gujarat, using a log-linear regression model. He observed that both the density of tractors and size of land holdings negatively influence the work animal density and the percentage of well irrigation positively influences the work animal density.

To explain the contribution of various factors on the work animal stock and also to capture the changes in the relative impact of these factors over time in Tamil Nadu, a set of indicators of agriculture, irrigation, agro-climatic condition, economic and institutional and technological status were correlated with the density of work animal population. The correlation coefficients were estimated for two sets of polled district-level data of Tamil Nadu; the first set represents the period between 1956 and 1974, and the second set for the period between 1977 and 1997 The above periodisation is made due to the shift observed in the size and composition of bovines from seventies. The results are given in Table 3

Table 3
Coefficient Correlation Between Density of Work Animal Population and Selected Indicators

Indicators		Correlation Coefficient	
		1956-1974	1977-1997
Agriculture Indicators	GCA / NSA	0.295	0.234
	FP / NSA	**0.421**	**0.500**
Irrigation Indicators	GIA / NIA	-0.111	0.090
	NIA / NSA	**0.386**	**0.284**
	WIA / NIA	0.024	0.133
	WIA / NSA	0.202	0.229
Climatic (Rainfall) Indicators	NSWR	**0.558**	**0.451**
	NNER	0.239	0.143
	NTR	0.310	0.234
	PNSWR	**0.593**	**0.530**
	PNNER	-0.103	-0.203
Institutional Indicators	NSA / CULT	**-0.470**	**-0.492**
	NSA / CULT2	**-0.426**	**-0.429**
Technological Indicators	NT / NSA	-0.227	-0.014
	NP / NSA	0.170	**0.422**
	MP / NSA	0.175	**0.356**
	PTP	0.008	**-0.385**
	PPP	0.012	-0.043
	PMP	0.013	-0.204

Note: 1WAP=Work Animal Population; NSA=Net Sown Area; GCA=Gross Cropped Area; GIA=Gross Irrigated Area; NIA=Net Irrigated Area; WIA=Well Irrigated Area; NSWR=Normal South West Rainfall; NNER=Normal North East Rainfall; NTR=Normal Total Rainfall; PNSWR=Percentage of Normal South West Rainfall; PNNER=Percentage of Normal North East Rainfall; CULT=Cultivators; NT=Number of Tractors; NP=Number of Pumpsets; PTP=Percentage of Tractor Power; PPP=Percentage of Pumpsets Power; FP=Farm Power; PMP=Percentage of Mechanical Power; MP=Mechanical Power.

2. Figures in bold denotes that they are significant at 5 per cent level.

The correlation coefficients indicated a significant association between the selected variables and the density of work animal population varied significantly over time. In 1956-74, the climatic factor was highly associated with the density of work animals, followed by size of landholding, agriculture and irrigation. In 1977-1994, the order is, climate followed by, agriculture, land holding, technology and irrigation. It can be seen that the technology indicators was not significantly associated during the former period, but it became highly significant during the later period. Our earlier findings support this observation. That is, there is a significant shift in the cultivation pattern (shift from the use of animal operated implements to tractor operated implements, animal and human power based cultivation to tractor and electrical power based cultivation pattern and traditional to modern cultivation) in the state and the shift is sharp from late-Seventies.

The cropping intensity (GCA/NSA) is observed to be positively related in both the phases, but not significant. This indicates that even if cropping intensity increased, it did not lead to any significant increase in the work animal density. To explain the reason behind this finding, one has to understand the animal use pattern across various seasons in a year. It has been argued earlier that possession of animals is conditioned not just due to its energy power, but also the flexibility of its availability. As work animals are relatively under-utilised, once cultivation becomes intensive, it would lead to a better utilisation of work animals and therefore no direct increase in the work animal stock is required. The growing contribution of farm power by mechanical equipments would also meet the increased draught power requirement in agriculture due to improvements in cropping intensity.

The association between farm power per cultivated area (FP/NSA) and density of work animals (WAP/NSA) is positive and significant. In fact, the association between these variables has increased from 0.421 to 0.5 during phase-I to phase-II. It indicates that in areas where the farm power requirement per cultivated area is higher, the animal density will also be high and vice-versa. The farm power per cultivated area, which represents the total agricultural performance in the context of draught power requirements, is contributed by animal power, electric power and mechanical power. It has been observed that the contribution of electric and mechanical power has been increasing in the state. In this context, the positively significant association observed between farm power per area and density of work animals indicate that animal power still occupies a significant position in Tamil Nadu agriculture.

Among the irrigation factors, the percentage of irrigated area to the cultivated area (NIA/NSA) alone was significantly correlated (positive) in both the phases. This indicates that when well irrigation improves it would lead to a better use of land for agriculture and it further increases the work animal density. But the findings of an association between the share of well irrigated area to the net irrigated area (WIA/NIA) and net sown area (WIA/NSA), which was positive, but not significant in both the phases, warrants further explanation. The insignificant contribution of well irrigation on work animal stock could be attributed to the energisation of wells by pumpsets and oil engines. Due to the mechanisation of well irrigation, although the well-irrigated area had increased, it had not raised the work animal population proportionally.

The South-West rainfall (NSWR) and the seasonal concentration of South-West Rainfall (PNSWR) were found to be significantly associated with the density of work animals, indicating that in areas where the south-west rainfall is more and the seasonal contribution of south-west monsoon is high, work animal density is also high and vice-versa. This supports our earlier argument of energy gate (Vaidyanathan (1988).

The average size of land holdings measured by the net sown area per cultivator (NSA/CULT) was found to be negatively associated with the density of work animals, significantly. When the population pressure on agricultural land increases, the NSA/CULT declines. That is, the average size of land holdings per cultivator declines over time. In this situation, the possession of work animals for cultivation purposes becomes crucial. As animals are indivisible in nature and their services are also sharable only to a limited extend due to the critical nature of farming and cultivation operations, the number of animals per household or farm increases when the size of land holdings declines or the fragmentation of landholding increases. However, this relationship would exist only up to a critical limit where farmers would find it difficult to maintain work animals due to the question of economic viability and productive efficiency or use pattern. Therefore, when the landholding declines beyond a limit, it would lead to a decline in the work animal density. This is evident from the square of the size of land holdings that associated with the density of work animals significantly indicating the non-linear association as argued by Vaidyanathan (1988).

Among the technological factors, a divergent association could be observed. The density of tractors (NT/NSA) was negative but not significant, in both the phases. This indicates that though tractorisation has a negative impact on the work animal population, its individual effect is insignificant. It is because that although the employment of tractor can displace work animals directly, it is possible only if the other areas of farming, landholding pattern and the economics of scale operation are conducive or jointly favourable. The density of pumpsets (NP/NSA) and mechanical power per cultivated area (MP/NSA) were positively associated with the work animal density, but the coefficients were significant only during phase-II. The percentage share of tractor power (PTP), pumpset power(PPP) and mechanical power(PMP) to the total farm power were positively associated during phase-I (though not significant), but became negatively associated in phase-II. During phase-II, the share of tractor power to the total farm power (PTP) alone was observed to be significantly associated with the work animal density, indicating that while the share of tractor power increases, the work animal density declines and vice-versa. It is important to observe that the trends in tractorisation, which gained importance in the Eighties and Nineties, had significantly influenced the work animal density negatively.

Although on a one to one basis many variables provided significant relationship, they were inter-related among themselves. For instance, the FP/NSA is significantly associated with the MP/NSA and NP/NSA. As the correlation coefficient between FP/NSA and WAP/NSA is found relatively high, FP/NSA is considered for the regression exercise.

Based on the procedure discussed above, two regression analyses are made, one representing phase I (1956-1974) and the other for phase II (1977-1994). Phase I basically represents the period when mechanisation in agriculture had been at the early stages and phase II represents the period when mechanization (both energisation of irrigation and tractorisation) was at a relatively higher level. A comparison of the results between these models would highlight the changes in the relative contribution of these factors over time. The regression models are explained below:

Model- I

WAP/NSA =f {NIA/NSA, PNSWR, NSA/CULT, NSA/CULT2, FP/NSA}

where, WAP/ NSA = Work Animal Population per Net Sown Area;
NIA/NSA = Net Irrigated Area per Net Sown Area,
PNSWR= Percentage of Normal South West Rainfall;
NSA/CULT = Net Sown Area per Cultivators,
NSA/CULT2 = Square of Net Sown Area per Cultivators,
FP/NSA = Farm Power per Net Sown Area.

Model II

WAP/NSA =f {NIA/NSA, PNSWR, NSA/CULT, NSA/CULT2, PTP, FP/NSA}

where, WAP/ NSA = Work Animal Population per Net Sown Area;
NIA/NSA = Net Irrigated Area per Net Sown Area,
PNSWR= Percentage of Normal South West Rainfall;
NSA/CULT = Net Sown Area per Cultivators,
NSA/CULT2 = Square of Net Sown Area per Cultivators,
PTP = Percentage of Tractor Power to the total Farm Power;
FP/NSA = Farm Power per Net Sown Area.

The regression results are given in Table 4

Table 4
Regression Results of Selected Variables on Density of Work Animal Population

		Indicators							**R2 value**	**N**
		Constant	NIA / NSA	PNSWR	NSA / CULT	NSA / CULT2	PTP / FP	FP / NSA		
1956-74	B - values	77.873	0.804***	1.339***	-0.839	0.002	----	0.084	0.712	**47**
	t- values	1.951	5.765	3.973	-1.549	1.013	----	1.375		
1977-97	B - values	99.802	0.719***	0.855***	-1.304***	0.004***	-1.966***	0.078**	0.674	**67**
	t- values	3.747	5.082	2.912	-3.589	3.272	-4.616	2.042		

*** indicates significance at 1 per cent level
** indicates significance at 10 per cent level.

The regression results for phase-I revealed that the seasonal concentration of rainfall and the percentage of irrigated area to the total cultivated area were the two significant factors that influenced the work animal density and the model explained 71 per cent of the variations in the density of work animals. The contribution of seasonal rainfall was observed to be the maximum (1.333), followed by percentage of irrigated area to the cultivated area (0.804). Though the size of landholding negatively contributed towards shaping the work animal density, its contribution was not significant. The farm power per cultivated area contributed positively, but its influence was also not significant. The signs of the coefficients for the variables obtained in our analysis are in the expected direction. However, the insignificant contributions made by size of landholding and farm power per area indicated that though these factors were contributing individually, their combined effect was not significant due to the dominant role played by the climatic and irrigation factors.

During Phase-II, all the variables included in the model significantly contributed towards work animal density and the model explained 67 per cent variations in the density of work animals. Among these factors, the contribution of the share of tractor power was dominant and that had negatively contributed to the work animal density (-1.966). The next major contribution was made by size of land holding that too negatively (-1.304). The relationship between the work animal density and size of land holdings is observed to be non-linear, and that is supported by the significant coefficients of the square of the size of land holdings. This means that when the size of land holding declines, the work animal density increases initially and beyond a limit, there exists a positive association between them. The contributions of seasonal rainfall and share of irrigated area were positive and almost equal (0.855 and 0.719 respectively). The farm power availability per cultivated area, which represents the agricultural power requirement, contributed positively (0.078).

The regression results obtained for Phase-II provides significant insights on the relative importance of various factors influencing work animal density and their contribution and help us draw certain inferences. The contribution of tractorisation has become dominant in influencing the density of work animals negatively indicating that tractorisation has played significant role in the displacement of work animal population in the recent years. The phenomenal increase in the number of tractors and power tillers from the Eighties corroborates this observation. As the pumpset revolution that began by the Seventies would have displaced the animals that were used for lifting water for irrigation purposes, once the cultivation and other farm activities were mechanised by tractors, the displacement of work animals became easier. It seems this sequence would have been under operation and this is reflected in the regression results as tractorisation contributed the maximum part.

The influence of average size of land holding on the work animal density supports the density-dependent hypothesis. It can be seen that the contribution of both climatic factor and irrigation had significantly reduced during phase-II, while these two factors contributed the maximum during phase-I.

In short, our analysis revealed that while the agro-climatic and irrigation factors had played a major role in shaping the work animal density during the period prior to mid-Seventies, the technological, economic and institutional factors played a major role in recent years.

References:

Dhas (1986): Structure of Milk Production in Tamilnadu: An Analysis of Trends and Sources of Growth, Unpublished M.Phil thesis, Centre for Development Studies, Jawaharlal Nehru University, New Delhi.

Dhas (1989): "Changes in Draught Animal Population and Its Effect on the Composition of the Bovine Stock in Tamilnadu", in Livestock Economy of India, Indian Society of Agricultural Economics, Oxford & IBH Publishing Co.Pvt.Ltd, New Delhi.

Mishra,S.N., and Sharma,Rishi K.(1990): Livestock Development in India: An Appraisal, Institute of Economic Growth, Vikas Publishing House Pvt. Ltd.,. New Delhi.

Nair,K.N. (1977): "Size and Utilization of Draught Animals in Kerala", Indian Journal of Agricultural Economics, Vol.32, No.4.

Saxena, Rakesh (1995): Status and Utilisation of Draught Animal Power in Gujarat, Working Paper No.93, Institute of Rural Management Anand

Vaidyanathan,A. (1978): "Aspects of Indias's Bovine Economy: Some Preliminary Results", Indian Journal of Agricultural Economics, Vol.33, No.1.

Vaidyanathan,A. And Nair, K.N. (1979): "A Comment on'Questions in the Sacred Cow Controversy' ", CDS Working Paper No.95, Centre for Development Studies, Trivandrum.

Vaidyanathan, A.(1988): Bovine Economy in India" CDS Monograph Series, Centre for Development Studies, Trivandrum and Oxford & IBH Publishing Co.Pvt.Ltd., New Delhi.

****