AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 72

1. SUBJECT CLASSIFICATION

A. PRIMARY
Food production and nutrition — AN10-0000-G635

B. SECONDARY
Agricultural engineering and structures--India

2. TITLE AND SUBTITLE
Livestock as a source of power in Indian agriculture,a brief review

3. AUTHOR(S)
Subrahmanyam,K.V.; Ryan,J.G.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1975	32p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
ICRISAT

8. SUPPLEMENTARY NOTES (*Sponsoring Organization, Publishers, Availability*)
(In Occasional paper no.12)

9. ABSTRACT

10. CONTROL NUMBER
PN-RAB-614

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Agricultural machinery
Animal husbandry
Cattle
India
Livestock
Power
Utilization

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ta-G-1073 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

AH20

AID/ta-G-1073 GTS
ICRISAT
PN-RAB-014

LIVESTOCK AS A SOURCE OF POWER IN INDIAN AGRICULTURE: A BRIEF REVIEW

K.V. Subrahmanyam

James G. Ryan

OCCASIONAL PAPER No.12
ECONOMICS DEPARTMENT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
HYDERABAD 500-016, INDIA
JULY 1975

Occasional Papers are informal reports of research or thoughts of ICRISAT staff members which are designed to stimulate thinking and comments of professional colleagues within and outside the Institute. These reports are not to be considered as formal publications bearing the endorsement of the Institute.

LIVESTOCK AS A SOURCE OF POWER IN INDIAN AGRICULTURE: A BRIEF REVIEW

K.V. Subrahmanyam & James G. Ryan*

Recently there has been a great effort to increase the productivity of land in India. The introduction of high yielding varieties (HYV's) has helped to achieve this objective to a large extent. Besides the direct contribution by way of additional yields, the HYV's have also contributed indirectly. Their major indirect contribution is in allowing multiple cropping because of their short duration. The pivotal element in multiple cropping is timeliness and all the operations have to be geared to meet a time schedule. Viewed from this angle power may become one of the important constraints for adopting recommended cropping patterns [21]. Bullocks being the chief source of power for most of the farmers in India, it is desirable to know the importance and limitations of this power source for facilitating change in cropping patterns. This review, though not exhaustive, attempts to focus on these points, within the limitations of available data.

---

* Research Associate and Economist, respectively, at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India. The authors would like to express their thanks to Drs. Matthias von Oppen, Hans P. Binswanger, Economists, Dr. N.S. Jodha, Associate Economist and Mr. H.S. Sandhu, Assistant Economist at the International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India, for their comments and valuable suggestions on an earlier draft of this paper. They of course are obsolved of any remaining sins of omission and/or commission.

Distribution Of Power And Present Pattern Of Utilization

Of the total effective power available in Indian agriculture in 1966 nearly 64 per cent was from draught animals, 25 per cent from human power and only 10 per cent from mechanical sources (Table 1). This clearly shows that animals are the chief source of power in Indian agriculture. A statewise analysis of the sources of power (other than human), presented in Table 2, also broadly shows the importance of animals as a source of power, though their contribution differs from state to state. Himachal Pradesh and Jammu and Kashmir are the two states where almost 100 per cent of the power is from animals. The Punjab has the smallest contribution from livestock at 57 per cent.

Bullock power on Indian farms appears to be relatively underutilised. From the Farm Management studies conducted in India in 1954, 1957, 1965, 1968 and 1969 in different states [5 to 12], it was estimated that the total number of eight hour days worked in a year by a bullock pair ranged from 64 to 165 days (Table 3). Though we cannot expect bullocks to work on all 365 days in a year due to rainy days, sickness, extreme heat, etc., it may be possible to work at least for 200 days in a year.[1/] An under-utilisation of between 17 and 68 per cent is indicated based on a 200 day work-year and more than 50 per cent when 365 days are considered

---

1/ See the later section on economic aspects of bullock power.

Table 1. Total available effective power for Indian agriculture, 1966

Source	Total population (1)	Effective population (2)	Horse power output per unit (3)	Effective total horse-power output available (4) [Col. 2 x Col. 3]
	Millions	Millions	HP	Million HP
Human Power:				
Male	200[a]	92[b]	0.10	9.20
Female	194[a]	52[b]	0.05	2.50
Animal Power (draught)	80	70	0.40	28.00
Electric Pumps (irrigation)	0.52	0.50	3.00	1.60
Electric-motor-operated Power (sugarcane crushers etc.)	0.04	0.04	5.00	0.20
Oil engines (irrigation, flour mills etc.)	0.30	0.26	5.00	1.30
Tractors	0.05	0.04	25.00	1.00
Total	-	-	-	43.80

a Rural

b Total agricultural labourers and cultivators

Source: Roy, S.E., [25, p. 491].

Table 2. Farm power input per hectare of net sown area from different sources in India by states[a]
(HP/ha.)

State	Live stock[b] power	Mechanical power			Total power input
		Tractor	Oil engine	Electrical pumps	
Andhra Pradesh	0.24 (86)	0.006	0.020	0.015	0.28
Assam	0.46 (98)	0.008	0.001	-[c]	0.47
Bihar	0.41 (98)	0.007	0.002	0.003	0.42
Gujarat	0.13 (65)	0.008	0.060	0.004	0.20
Haryana	0.11 (69)	0.035	0.005	0.010	0.16
Himachal Pradesh	0.52 (100)	0.001	-	-	0.52
Jammu and Kashmir	0.36 (99)	0.004	-	-	0.36
Karnataka	0.16 (89)	0.006	0.010	0.008	0.18
Kerala	0.15 (88)	0.004	0.016	0.007	0.17
Madhya Pradesh	0.24 (96)	0.004	0.005	0.001	0.25
Maharashtra	0.15 (75)	0.004	0.040	0.006	0.20
Orissa	0.33 (97)	0.002	0.001	-	0.34
Punjab	0.16 (57)	0.068	0.033	0.016	0.28
Rajasthan	0.12 (92)	0.007	0.002	0.001	0.13
Tamil Nadu	0.36 (70)	0.013	0.035	0.103	0.51
Uttar Pradesh	0.34 (94)	0.015	0.008	0.002	0.36
West Bengal	0.39 (98)	0.007	0.004	-	0.40
All India	0.24 (89)	0.009	0.017	0.009	0.27

a Figures in brackets are percentage to total.
Calculated from livestock and agricultural machinery data collected during 1966 [4, p. 50,51] and net area sown during 1966-67 [13]. Excludes the human power input. Each unit of livestock is considered equal to 0.4 HP, each tractor as 25 HP, oil engines 5 HP and electrical motors 3 HP [25,p.491].

b Only male cattle and buffaloes over 3 years were considered. Though other livestock like camels, cows etc., are used for agricultural operations, in the absence of availability of usable data, they are not considered.

c A dash (-) indicates a negligible amount.

Table 3. Distribution of total work days of a pair of owned bullocks for different purposes per annum[a]

(In bullock pair days)

State	Cropping pattern	On the farm	Off the Farm					Total work days employed
			Exchange or gratis	Hired out	Service and business	Social and family affairs	Total work off the farm	
Andhra Pradesh (West Godavari District)	Paddy	70.9 (73.54)	10.7 (11.09)	12.60 (13.07)	0.40 (0.40)	1.8 (1.8)	25.5 (26.46)	96.40 (100.00)
Andhra Pradesh (Cuddapah District)	Paddy, Jowar, Groundnut	53.21 (76.92)	9.69 (14.00)	3.81 (5.51)	-	2.47 (3.57)	15.97 (23.08)	69.18 (100.00)
Madhya Pradesh (Raipur District)	Paddy, Urad and Wheat	53.39 (82.51)	7.81 (12.07)	2.52 (3.09)	-	0.99 (1.53)	11.32 (16.69)	64.71 (100.00)
Orissa (Cuttack District)	Paddy	78.30 (78.82)	N.A.[b]	N.A.	N.A.	N.A.	21.04 (21.13)	99.34 (100.00)
Punjab	—	133.56 (98.08)	N.A.	N.A.	N.A.	N.A.	11.64 (8.92)	145.20 (100.00)
Punjab (Ferozepur District)	Wheat, Paddy and Cotton	133.00 (93.66)	7.00 (4.93)	-	-	2.00 (1.41)	9.00 (6.34)	142.00 (100.00)
Uttar Pradesh	—	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	165.00 (100.00)

a Figures in brackets are percentages

Source: Directorate of Economics and Statistics, [5 to 11]; Economics and Statistical Organizations[12] .

b N.A. - Not Available

as the work-year. The extent of underutilisation does not seem to be systematically related to farm size or extent of irrigation, as is evident from the data presented in Tables 4 and 5.

Not only is bullock power apparently underutilised but the work-load also is not uniformly distributed throughout the year. This can be seen from the monthly employment pattern presented in Table 6. In the regions having extensive irrigation facilities providing the scope for multiple cropping such as in Ferozepur, one finds a more uniform pattern and extent of utilisation. On the other hand, in regions like Cuttack, Pali and Raipur where the scope for growing crops in more than one season does not exist, the overall utilisation is less and largely confined to certain peak periods. Generally, depending on the agro-climatic region, the peak periods will be either June-July or December-January for kharif tracts and October-November for rabi tracts. In the other periods bullocks are employed for only a few days per month. The rest of the time they apparently remain idle.

Qualitative Aspects of Bullock Power 2/

In this section the different breeds of cattle in India and other details relevant to the problem of draught power are discussed.

---

2 / Few data are available regarding the qualitative aspects of bullock labour as draught power. The little that is available is presented in this section.

Table 4. Average employment of owned bullocks per year on farms of different size, 1969-70[a]

(In bullock pair days)

Size group (Hectares)	Farm work	Off the farm[b]	Total days employed	Days unemployed in a year
(A) CUDDAPAH DISTRICT OF ANDHRA PRADESH				
Below 1.62	54.98	26.19	81.17 (22)	283.83 (78)
1.63 - 3.23	48.16	29.43	77.59 (21)	287.41 (79)
3.24 - 6.06	44.80	12.78	57.58 (16)	307.42 (84)
6.07 - 11.33	55.47	11.48	66.95 (18)	298.05 (82)
11.34 and above	59.74	13.61	73.35 (20)	291.65 (80)
All Farms	53.21	15.97	69.18 (19)	295.82 (81)
(B) FEROZEPUR DISTRICT OF PUNJAB				
Below 6	111	13	124 (34)	241 (66)
6 - 9	125	4	129 (35)	236 (65)
9 - 14	132	11	143 (39)	222 (61)
14 - 24	142	6	148 (40)	217 (60)
24 and above	168	9	177 (48)	188 (52)
All Farms	133	9	142 (39)	223 (61)

a Figures in brackets are percentages.

Source: Directorate of Economics and Statistics [5,pp. 73-74 and 8,pp. 63-64].

b Includes days employed for exchange or gratis, hired out and social and family affairs etc.

Table 5. Employment of bullocks by size and type of farms in Karimnagar District (Andhra Pradesh) 1964-65[a]

	Percentage of total days	
	Total days worked	Total days unemployed
	%	%
Irrigated:		
Small (upto 2.0 ha.)	61.22	38.78
Medium (2-6 ha.)	58.16	41.84
Large (above 6 ha.)	39.73	60.57
All irrigated farms	49.05	50.95
Unirrigated:		
Small (upto 2.0 ha.)	28.17	71.83
Medium (2-6 ha.)	57.78	42.22
Large (above 6 ha.)	51.23	48.77
All unirrigated farms	48.82	51.18

a Source: Department of Agricultural Economics, [3, Table No.HS. 2.18] .

Table 6. Monthly employment of draught animals per pair on farms[a]

(In bullock pair days)

Months	Ferozepur[b] (Punjab) 1969-70	Cuttack Dist.[c] (Orissa) 1968-69	Pali Dist.[b] (Rajasthan) 1963-65	Raipur (Madhya Pradesh) 1963-65
	Important Crops			
	Wheat, Paddy and Cotton	Paddy	Jowar and Wheat	Paddy
June	-	26.82	-	9.76
July	13.30	14.44	14.00	8.70
August	13.59	7.48	9.00	4.22
September	13.40	2.12	6.00	0.49
October	17.78	2.38	8.00	2.59
November	17.29	2.68	8.00	4.74
December	10.33	6.95	11.00	12.12
January	6.01	2.99	13.00	6.81
February	8.38	5.62	8.00	3.13
March	10.81	1.01	6.00	3.29
April	9.14	0.96	6.00	3.81
May	12.33	4.85	4.00	5.05
June	9.42	-	6.00	-
Total	141.78	78.30	99.00	64.71

a Source: Directorate of Economics and Statistics [8, p. 65, 7, p. 30, 9, p. 24 and 10, p. 26].

b Includes other than crop production also.

c Used for crop production only.

Broadly speaking the Indian breeds of cattle can be classified into three categories.

(a) Milch Breeds : These cows are high yielders. The bullocks are moderate type or of poor draught quality. Examples are the Gir, Sindhi, Sahiwal and the Deesi.

(b) General Utility Breeds : These cows are fairly good milkers and the bullocks are good for draught purposes. Examples are the Hariana, Ongole, Gaolao, Krishna Valley, Tharparkar and Kankraj.

(c) Draught Breeds : These cows are poor milkers but the bullocks are excellent draught animals. Examples are the Naguri, Bachaur, Keukatha, Malvi, Kherigarh, Hallikar, Amritmahal, Kangayam, Khillari, Ponwar and Siri.

Though different breeds are used in different parts of the country, one can assume that the general utility breeds and draught breeds are mostly used for farm work in view of their reputation. The most popular breeds for farm work along with their average body weights are presented in Table 7.

Draught Power: The draught exerted by animals is directly proportional to their body weight, though it is influenced to some extent by other factors like method of hitching the implements, the type of yoke used

Table 7. Average body weight of mature bullocks of the main Indian breeds used in farm work[a]

Breed	Average body weight
	Kg.
Nimari	304
Nagori	318
Siri	318
Sahiwal	408
Gaolao	408
Tharparkar	431
Kangayam	522
Deoni	522
Hariana	508
Krishna Valley	544
Kankrej	544
Average	439

a. Source: Indian Council of Agricultural Research, [14, p. 581].

etc. From observations made at different locations as shown in Table 8, one can conclude that bullocks can exert roughly eight to twenty per cent of their body weight as draught. The average weight of bullocks used in farm work is about 440 kilograms (Table 7), with a range of from 300 to 544 kilograms. Therefore the draught which could be exerted by bullocks should range from 24 to 110 kilograms, depending upon the location, maintenance conditions, type of implements used etc. The large variation in draught exertion has an important bearing on the design of bullock drawn implements. The implements designed should not be too heavy, requiring a large draught force, as it will be a strain particularly for smaller bullocks, thus reducing their work efficiency. One has to keep in mind the type of animals that are used in the particular area while designing implements.

In terms of horse power, a pair of bullocks while ploughing has a range of from 0.29 to 1.87 and they walk at a speed of between 1.7 and 1.8 miles per hour, slowing down to 1.2 miles per hour at the end of a day's work [14]. Based on the above speeds, a pair of bullocks can cover 0.2 to 0.3 acres per day with a desi plough and 0.5 to 1.0 acres per day with a medium type of mouldboard plough in an alluvial soil [14]. The exact coverage will of course depend upon the location, type of implement used,

Table 8. Body weight of bullocks and draught exerted in ploughing[a]

Average body weight per pair of bullocks	Locality	Draught	Draught/Weight ratio
Kg.		Kg.	
431	Bankura	67	0.15
454	Tripura	45	0.10
454	Patna	54	0.12
726	Jhansi	61	0.08
771	Delhi	66	0.09
771	Aligharh	78	0.10
771	Coimbatore	149	0.19
907	Baroda	139	0.15
953	Karnal	135	0.14
1111	Indore	183	0.16

a Source: Indian Council of Agricultural Research, [14, p. 580].

the previous weather, and the operation. For example in Punjab regions it will take 8 to 10 hours to plough an acre of land with a desi plough to a depth of 4-5", whereas it will take 10 to 12 hours with a mould-board plough for ploughing to a depth of 5½" to 6". Operations like planking with an implement weighing 75 Kg. will take only 2 to 2.5 hours [26 pp. 55, 60].

Performance of bullocks in different seasons : The data in a recent experiment conducted on the physiological aspects of crossbread and Hariana bullocks at the National Dairy Research Institute, Karnal [28] presented in Table 9, indicates the area ploughed by bullocks in six hours is at a maximum in winter and at a minimum in the hot-humid periods. Besides this, cross-bred bullock performance is comparatively poorer than the Indian-bred Hariana. This is an important point to be kept in mind while launching programmes for upgrading the existing cattle by artificial insemination with exotic breeds as farmers may not like to have bullocks which are not good at farm work as long as bullocks will remain their chief source of draught power.

Economic Aspects of Bullock Power

The data available from the Farm Management Studies in India during 1968-69 and 1969-70, [7,8] has shown that the net cost of

Table 9. Work capacity of cross-bred and Hariana bullocks[a]

Breed	Season	Pulse rate/minute			Respiration rate/minute			Area ploughed in six hours
		Initial	Four hours of continuous work	Difference	Initial	Four hours of continuous work	Difference	
								Sq. meters.
Cross-bred	Winter	63	79	16	24	35	11	2970
Hariana	"	49	60	11	23	35	12	3320
Cross-bred	Summer	60	78	18	34	60	26	2860
Hariana	"	51	70	19	25	42	17	3070
Cross-bred	Hot humid	59	78	19	45	69	24	2440
Hariana	"	51	66	15	35	52	17	2903

a Source: Usha Anand and Sundaresan [28, p. 29]. The data represent the average for three pairs in each group.

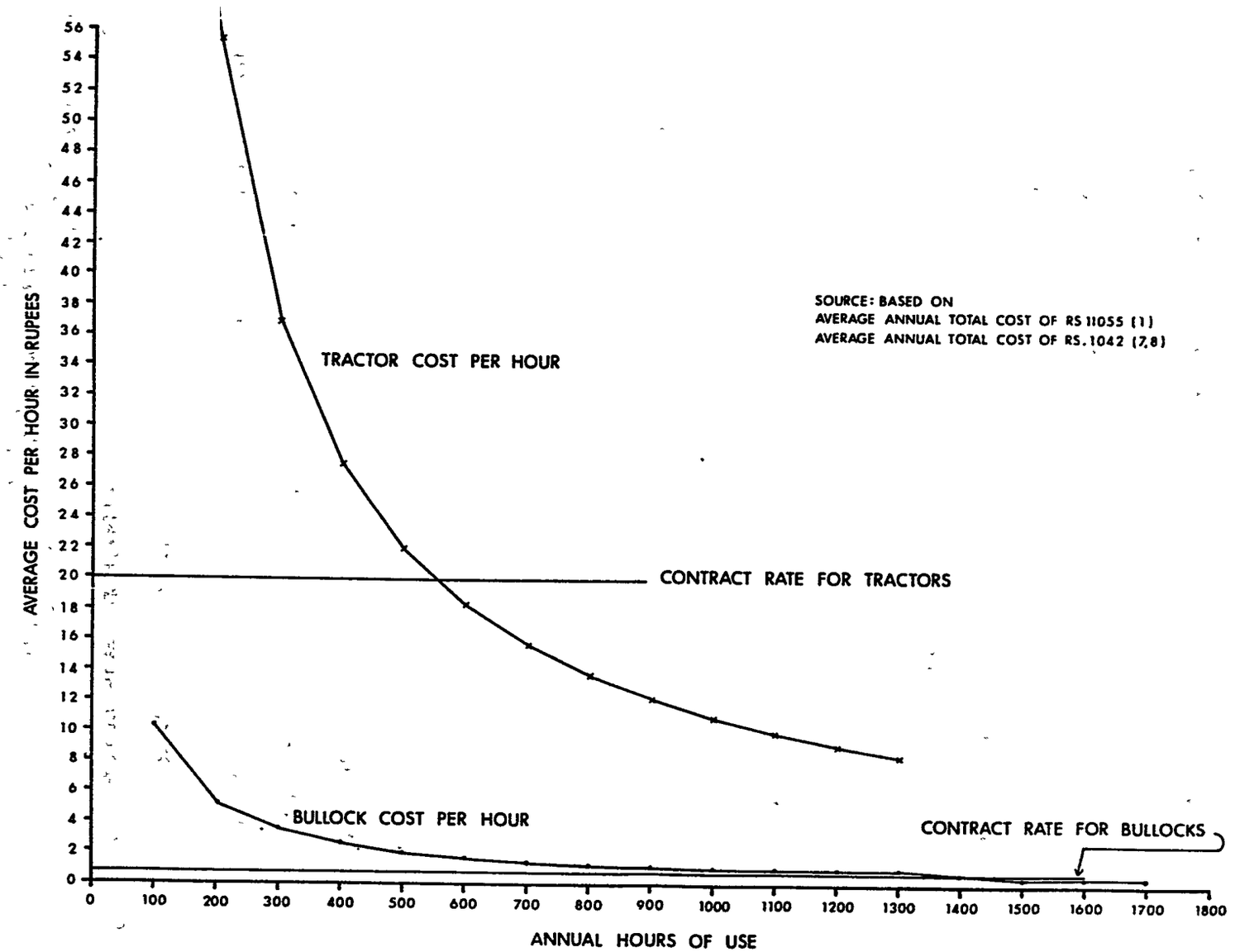
maintenance of a pair of bullocks ranged from Rs. 370 to Rs. 1713 per year.[3] Of course the exact cost of maintenance will depend on the size of bullocks, the imputed cost of home-produced feeds, the type of concentrates fed and also the number of days worked, all of which vary from region to region. Based on the average cost of maintenance of Rs. 1042 per year per pair from these studies, the cost of working per hour at different hours of use per year per pair is shown in Figure 1. The slope of the cost curve is almost flat after 1600 hours of use, showing that there may not be any significant decline in costs above this level of use. At the present prevailing hiring charges of Rs. 0.75 per hour (excluding the operator's charges) it seems to be more profitable to hire than to own a pair of bullocks unless one can think of having an annual use of nearly 1400 hours or 175 eight-hour days.

The present pattern of utilisation presented in Table 3 of the earlier section shows in majority of cases that the number of bullock-days utilised is well below the optimum, computed from Figure 1, of 175 days. But still we find that in the majority of cases farmers who have only 2 or 3 acres of land also own a pair of bullocks.

---

3 Includes both fixed costs like depreciation, interest and shelter and variable costs like feed, labour and others.

FIGURE: 1. AVERAGE COST CURVES FOR BULLOCK AND TRACTOR POWER.



This may be because : (1) most of the feed of the livestock being byproducts involve no extra cost of production, although the opportunity cost of feeding byproducts to bullocks is positive whenever there is a market for them. Besides the fodder produced on the farms, the feed requirements of livestock are supplemented by grazing in community pastures and on the grasses grown on the field bunds which involve no significant extra cost; (2) it may be difficult to hire a pair of bullocks in the peak season as most of the bullock owners may be anxious to complete their work in time, this implies that the "real cost" of hiring bullocks is higher than the cash charge of Rs. 0.75 per hour; or (3) a farmer may take into account only the out of pocket expenses incurred and may not bother about the imputed costs. The out of pocket expenses for the majority of farms will be very small because feed/fodder and labour expenses comprise the bulk of the cost of maintenance and these are rarely paid for. As mentioned earlier, fodder from crop byproducts, grazing lands and field bunds is normally available free of charge. Regarding labour, there is not much extra cost involved as the farm family can look after the bullocks even while doing other work.

Given this situation there may be number of ways of improving the present state of affairs :

(1) Firstly, as most of the small farmers already have a pair of bul-

locks, one should try to increase the utilisation of bullocks to at least 200 days in a year. This must come primarily through utilisation in crop production as the scope for hiring out is negligibel in the majority of the cases except of course in peak periods which is when their value to their owners is at its peak. This aspect is discussed in detail in the next section.

(2) Alternatively the farmers might want to switch to mechanical power if that is cheaper than bullock power.

Before one advocates such a change, one has to analyse the costs and benefits associated with bullock and tractor power and their relative desirability and feasibility in a given situation. Based on an average cost of maintenance (fixed + variable) of Rs. 11055 per annum for different makes of 35 HP tractors from the study conducted by Acharya *et al.* [1], the average hourly cost of maintenance for different hours of use in a year is presented in Figure 1, along with bullock pair data. At the rate of Rs. 20/- per hour for hiring a tractor an annual use of nearly 550 hours seems to be enough to justify owning a tractor as against 1400 hours of use required to justify owning a pair of bullocks. From the point of view of energy per unit time (HP hour) Table 10 shows the mechanical source of power seems to cost at least 50 per cent less than animal power. But when one tries to compare the cost of performing an operation, it seems that animal power is nearly as costly as that of

Table 10. Comparision of costs of bullock and tractor draught power, 1969-70.

Item	Unit	Bullock pair	Tractor (35 HP)
Capital investment[a]	Rs.	1000 to 2000	18065
Maintenance cost per hour[b]	Rs.	1.76	13.63
Maintenance cost of energy per HP hour[c]	Rs.	1.46	0.48
Performance rate per hour[d] (for ploughing 6"-8" deep)	Ha.	0.03	0.26
Maintenance cost of an operation (ploughing) per hectare	Rs.	52.80	53.79[e]

a This varies according to size of bullocks, age etc. In the case of tractors it is an average of four makes of the tractor and excludes the cost of accessories [1, p. 8, Table 2].

b This is based on an average maintenance cost (fixed plus variable) of Rs. 1,042 per pair per year and an average of 828 hours of use per year, from the Farm Management Studies [5,7 and 8]. It includes Rs. 0.50 per hour for the operators cost. For tractors it is based on annual use of 824 hours [1, p. 12, Table 8] and an average total annual operating cost for tractors of different makes of Rs. 11,055 [1, p. 11], including operator labour. The costs of labour are included for both bullocks and tractors.

c This is based on a conversion factor of 1 pair hour = 1.2 HP hours for bullocks and a 35 HP tractor which can supply 28.4 drawbar HP.

d For bullocks based on an input coefficient of 12 hours per acre for ploughing to a depth of 6" [26, pp. 55,60]. For tractors from the Acharyas study [1, p. 13, Table 10].

e Average for different makes of tractors [1, p. 13, Table 10].

mechanical power. The greatest draw back of the mechanical source of power is the need for a large initial capital investment, which is sixteen to thirty four times that required for bullocks. The greatest advantage of tractor power is its ability to cover a larger area per unit time. It can plough 0.25 hectares in an hour whereas bullocks can cover hardly 0.03 hectares. This has implications for timeliness of operations when the period available is limited and the area to be covered is large. This may be part of the reason for the recent spread of tractorisation to relatively dry areas.[4]

To further examine this aspect of mechanisation an attempt was made to derive the area that can be commanded by bullocks and tractors on red and black soils in Hyderabad. For this purpose the average number of rainfree days in each month were obtained after deducting the average number of rainydays in a month from thirty years of rainfall data in the India Meteorological Department [15, p. 253]. Then the days available for operations in each month were calculated based on the assumption that all the rainfree days

---

4 For details see the paper by Jodha [16].

are available for operations for both tractors and bullocks on red soils. In black soils, however, it was assumed that soils cannot be worked for 1½ times the number of rainy days with bullocks and 1¾ times the number of rainy days with tractors. Based on the input coefficients for different operations for bullocks and tractors from the Singh *et al.* [26] and the timing of operations, the area that can be commanded in each month for carrying out that operation was worked out from the number of days available for the operations. The smallest command area figure amongst all the months was taken as the maximum possible command area. The results of this analysis are presented in Table 11. The most time consuming and as such the most limiting operation is ploughing and sowing in the month of June, and so this is the operation which determines the command area. On red soils bullocks can command an area of nearly 3 hectares and tractors can command an area of 18 hectares, whereas on black soils bullocks can command an area of 2.5 hectares and tractors an area of nearly 14 hectares. This means that tractors can command an area nearly six times larger than that of bullocks. This illustrates the limitations which bullocks have as the source of draught power for timeliness of operations where the area to be managed is large. No doubt the present analysis is a crude one and one has to be cautious in interpreting the results. But nonetheless, this indicates the need to gather more of this type of information to determine power constraints in different regions and

Table 11. Days available and the area commanded by bullock and tractor draught power for various operations on red and black soils at Hyderabad, India

Items	Unit	January	February	March	April	May	June	July	August	September	October	November	December
Total normal rainfall[a]	m.m.	1.7	11.4	13.4	24.1	30.0	107.4	165.0	146.9	163.3	70.8	24.9	5.5
No. of rainy days[a]	No.	0.2	0.8	1.1	1.8	2.7	6.9	11.5	10.2	10.1	4.9	1.7	0.4
Average rainfall per day	m.m.	-	-	12.18	12.39	11.11	-	15.56	14.35	14.40	16.17	14.45	-
No. of rain-free days	No.	30	27	29	28	28	23	19	20	19	26	28	30
Red Soils:													
No. of days available for[b] operations	No.	30	27	29	28	28	23	19	20	19	26	28	30
Name of operation			Irrigation			Ploughing (Kharif)	Ploughing + sowing (Kharif)		Interculture		Ploughing + sowing (Rabi)	Irrigation	Interculture + irrigation.
Number of operations	No.	1				3	2 + 1		1		2+1	1	1+1
No. of hours required/ha. : [c]													
- Bullocks	Hours/ha.	31				60	60		20		60	31	51
- Tractors	"	-				12	10		2		10	-	2[d]
Maximum number of hectares that can be covered:[e]													
- Bullocks	Hectares	7				3.7	3.1[f]		8.0		3.7	7.2	4.7
- Tractors	Hectares	-				18.6	18.4		76.0		20.8	-	120.0

(Contd...)

Table 11. (Contd..)

Item	Unit	January	February	March	April	May	June	July	August	September	October	November	December
Black soils:													
No. of days available for operations[b]:													
- Bullocks	No.	30	26	28	27	26	19	13	16	15	23	27	30
- Tractors	No.		26	28	26	26	18	10	13	12	22	27	30
Name of operation						Ploughing (Kharif)	Ploughing + Sowing		Interculture		Ploughing + Sowing (Rabi)	Irrigation	Interculture + Irrigation
No. of operations	No.					3	2+1		1		2+1	1	1+1
No. of hours required/ha.[c]:													
- Bullocks	Hours/ha.		31			60	60		20		60	31	51
- Tractors	"		-			12	10		2		10	-	2[d]
Maximum number of hectares that can be covered[c]:													
- Bullocks	Ha.		6.7			3.5	2.5[f]		6.4		3.1	7.0	6.7
- Tractors	Ha.		-			17.3	14.4		52.0		17.6	-	120.0

a Data are for Hyderabad. Source: Indian Meteorological Department [15, p. 253].

b In the case of red soils all the rain-free days are assumed to be available for operations. In the case of black soils for bullocks 150 per cent of the rainy days are assumed to be not available for operations. For tractors 175 per cent of the rainy days are assumed to be not available for operations. The figures are rounded of to the nearest degit.

c Source: Singh et al. [26, p. 55 - 88].

d Only for interculture.

e For calculating the total number of hours available, the number of days available are multiplied by eight as a day was assumed to contain eight working hours.

f The underlined figures show the feasible command area of the draught power, as it is the limiting area based on the available days and operations.

to examine the necessity and desirability of mechanization.

From the foregoing analysis, one may conclude that there are advantages in using tractor power, but in view of the large initial capital investment higher per operation cost of tractors and because of the predominance of small farms which can be managed with bullocks, it may not be feasible in the near future for a large-scale conversion to mechanical power. Even if the government or private organizations are willing to provide custom-hire services, unless proper infrastructural facilities in the form of organised channels for marketing the byproducts of the crops grown by farmers are provided and industries such as dairying are developed for profitable use of feed saved from displaced bullocks, they will remain the primary source of farm power in India. This type of change may not occur very rapidly. This means that it will be very important in the near future to focus on better utilization of draft animal power.

Scope for Improving the Utilization of Bullock Labour

One could think of broadly two ways to improve the extent of utilization:

1) Developing cropping schemes which will increase utilization. In this context practices like multiple cropping, mixed cropping, relay cropping etc. can be introduced. For example, instead of keeping land fallow in the rabi season growing a crop like safflower might be recommended, which not only uses available land resources but also increases the use of bullock labour. Sowing a relay crop like safflower or chickpea in a standing crop of jowar or pearl millet is another possibility.

2) Developing resource management practices which can be performed in the off-season by bullocks. In this category there are practices like (i) timing of tillage operations, i.e., ploughing the land immediately after harvest as is done at present at ICRISAT; (ii) interculture operations like harrowing for soil moisture conservation; (iii) spacing crops so that certain operations like weeding can be done with bullock-operated implements; (iv) land and water improvements designed to more effectively utilise monsoon rainfall and reduce soil erosion.

The operational feasibility of these measures would largely depend upon physical, economic and social factors which are highly region specific. Physical factors like climate, soils and the extent of irrigation facilities will largely influence the choice of crops and crop sequences. Economic factors like availability of capital and other resources, and social factors like attitude of farmers will also influence their acceptability.

Conclusion

The aim of this brief review has been to bring out the importance and limitations of bullock power in Indian agriculture so that researchers can keep them in mind while developing cropping programmes, soil and water management techniques, and designing bullock-drawn implements. The bullock power resource in India is an extremely valuable one and it is important that it be used to the fullest extent.

REFERENCES

[1] Acharya, T.K.T., J.R. Pawar, and B.B. Jhorat., " Relative Economic Efficiency of Different Makes of Tractors on Tractorised Farms in Karad Taluk ", *Agriculture and Agro-Industrial Journal*, 7(11):7-14, November, 1974.

[2] Bhattacharyajee, T.P., " A Note on Cattle in Indian Farm Economy ", *Indian Journal of Agricultural Economics*, Selected Readings, 1940-64, pp. 303-311.

[3] Department of Agricultural Economics and Statistics, *Study in the Agro-Economics Effects of Lift Irrigation in Andhra Pradesh*, Report for the years 1962-65, College of Agriculture, Andhra Pradesh Agricultural University, Hyderabad, India.

[4] Directorate of Economics and Statistics, *Indian Agriculture in Brief*, Thirteenth edition, Ministry of Agriculture, Government of India, New Delhi, 1974.

[5] _____, *Studies in the Economics of Farm Management in Cuddapah District (Andhra Pradesh)*, Report for the year 1969-70, Ministry of Agriculture, Government of India, 1974, pp. 72-79.

[6] _____, *Studies in the Economics of Farm Management in West Godavari District (Andhra Pradesh)*, Report for the year 1957, Ministry of Agriculture, Government of India.

[7] _____, *Studies in the Economics of Farm Management in Cuttack District (Orissa)*, Report for the year 1968-69, Ministry of Agriculture, Government of India, 1973, pp. 29-33.

[8] _____, *Studies in the Economics of Farm Management in Ferozepur District (Punjab)*, Report for the year 1969-70, Ministry of Agriculture, Government of India, 1973, pp. 62-69.

[9] _____, *Studies in the Economics of Farm Management in Pali District (Rajasthan)*, Combined Report for the year 1962-63 to 1964-65, Ministry of Agriculture, Government of India, New Delhi, 1973, pp. 23-25.

[10] _____, *Studies in the Economics of Farm Management in Raipur District (Madhya Pradesh)*, Combined Report for the years 1962-63 to 1964-65, Ministry of Agriculture, New Delhi, 1972, pp. 25-29.

[11] Directorate of Economics and Statistics, *Studies in the Economics of Farm Management in Uttar Pradesh,* Report for the year 1954-55, Ministry of Agriculture, Government of India, New Delhi.

[12] Economics and Statistical Organization, *Studies on the Economics of Farm Management in Punjab,* Report for the year 1961-62, Government of Punjab, Chandigarh (India).

[13] Fertilizer Association of India, *Fertilizer Statistics,* 1969-70, Fertilizer Association of India, New Delhi, 1970.

[14] Indian Council of Agricultural Research, *Handbook of Agriculture,* Indian Council of Agricultural Research, New Delhi, 1969, pp. 180-181.

[15] Indian Meteorological Department, *Climatological Tables of Observatories in India,* 1931-60, Government of India.

[16] Jodha, N.S., " A Case of the Process of Tractorization ", *Economic and Political Weekly,* 9(52): A 111 - A 118, December 28, 1974.

[17] Mittal, J.P., R.P. Saxena and I.J. Singh, " A Mathematical Expression for Cost Analysis of Farm Equipments ", *Indian Journal of Agricultural Economics,* 29(1):51-59, January-March, 1974.

[18] National Sample Survey, *The Tables with Notes on Some Aspects of Land Holdings in Rural Areas (States and All India Estimates),* Seventeenth Round, September, 1961-July 1962, The Cabinet Secretariat, Government of India, New Delhi.

[19] _____, *Tables with Notes on Some Aspects of Land Holdings in Rural Areas (States and All India Estimates)* Number 162, Seventeenth Round, September 1961-July 1962, The Cabinet Secretariat, Government of India, New Delhi.

[20] Nyholm, K., Henrik Schanmburg Miller and Kristen Westergood, " Socio-Economic Aspects of Dairy Development - Report from the Bangalore Milkshed Area " *Economic and Political Weekly,* 9(52): A 127 - A 136, December 28, 1974.

[21] Panda, H., " Power Supply Limits Adoption of Recommended Cropping Patterns in Irrigated Deltaic Areas ", *Cropping Patterns in India,* Proceedings of the Symposium on Cropping Patterns in India, Indian Council of Agricultural Research, 1968 pp. 528-530.

[22] Punjab Agricultural University, *Punjab Agricultural Handbook*, Punjab Agricultural University, Ludhiana, 1968.

[23] Randhawa, M.S., *Agriculture and Animal Husbandry in India*, Indian Council of Agricultural Research, New Delhi, 1958.

[24] Raut, K.C., V.N. Amble and Shivtar Singh, *Economics of Raising Cattle and Buffalces*, Institute of Agricultural Research Statistics (Indian Council of Agricultural Research), New Delhi, 1973.

[25] Roy, S.E., " Agricultural Engineering " *Agricultural Yearbook*, New Vistas in Crop Yields, Indian Council of Agricultural Research, 1970, pp. 489-607.

[26] Singh, Inderjit., Richard H. Day and S.S. Johl, *Field Crop Technology in the Punjab, India*, Social Systems Research Institute, University of Wisconsin, Madison, Wisconsin, 1968, pp. 55-88.

[27] Singh, Kripal., and J.P. Harbouszky, " An Economic Analysis of Bullock Labour Use in Delhi Farming ", *Indian Journal of Agricultural Economics*, 20(4):17-28, October-December, 1965.

[28] Usha Anand and D. Sundaresan, " Cross-Bred Bullocks can Contribute to Agriculture Operations ", *Indian Farming*, 24(5):27-29, August 1974.