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AGRO-MECHANICAL TECHNOLOGY IN GUJARAT*

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Mechanical aids, machinery, tools and implements, are a component of new technology in the agricultural system. Broadly, the agricultural system consists of input segment, on-farm segment and the output segment. Mechanical aids are increasingly being incorporated in all these three segments. The two segments, input and output, usually take more readily to mechanization. This is due to the fact that scales/volumes are larger in these segments, there is flexibility in the location of units, the technology is more easily available and for these reasons, it is more attractive to entrepreneurs. The difficulties are greater in the transformation of the central segment—the farms which is the focus of this paper. The aim is to analyse the growth in the use of mechanical technology on farms in Gujarat. The focus will be on operations upto harvesting.

Four distinct situations can be observed in mechanization in cultivation. First, where man provides his own power and uses his body parts, hand, foot to perform work. In this paper this will be referred to as the situation of no mechanization. Cotton picking, transplanting of paddy, manual milking can be the examples.

The second stage is where man continues to be the source of power, but employs tools instead of his body parts to perform the task. For example, the use of a trolley to transport farm produce, harvesting of crop with sickle, pulling of cotton stalks with stalk-puller (Chepio), use of sling to scare away bird pests, etc. More and more sophisticated and a wider range of manual tools may be used to perform complicated and larger number of tasks. This situation represents the beginning of mechanization.

The third stage of mechanization is where man gives up being the source of power as well. He uses external power and tools to do the work. The man retains the logistical functions of operating and guiding. For example, walking behind a bullock driven plough, steering a tractor on which is mounted agricultural equipment, driving a bullock cart, etc.

The fourth, and perhaps, the 'highest' degree of mechanization is the installation of automatically controlled systems, where even the logistical function is transferred from man to, say, a computer which in turn guides the equipment and power unit for performance of a task. Computer controlled irrigation system can be an example.

Keeping in mind the above four situations, one can construct two indices of mechanization. The first, the degree of change in power source. In our context it will mean determining the degree to which draft animals are being

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I am grateful to Shri Amar Jeet Singh who has helped in revising this paper.

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substituted by tractors and other mechanical units. The second index can be the changes in the use of tools and implements. In what follows, we shall characterize the Gujarat situation on the basis of these two indices.

THE DATA AND METHOD

There have been four livestock censuses in Gujarat since its formation. The fifth is just over but its results are not yet available. There has been one agricultural census (1977) whose results are now available. These two sources have been used here. We have taken the presence of machinery and equipment as a measure of their use. This can in certain cases lead to certain inaccuracy. Some micro studies have been referred to in order to corroborate and thus minimize the inaccuracies.

MECHANIZATION IN GUJARAT

Change in Power Source

This change can take place in two ways, by introduction of *mobile* power units such as tractors and power tillers. It can also take place through introduction of self powered equipment such as pumpsets, stationary threshers, etc. The change in power units of the first type, mobile, is most important. For, these, being multipurpose, set in motion the process of mechanization which gradually covers more and more operations depending on the availability and comparative advantages of specific implements.

(*a*) *Mobile Power Sources*

In 1961, for every 1,000 hectares (ha.) of cultivated land, there were 151 pairs of draft cattle, 125 labourers and only 0.2 tractor. The presence of tractors was negligible, the important power sources were the cattle. By 1977, the situation had changed to an extent. For each 1,000 ha. of cultivated land there were 143 pairs of draft cattle, 241 labourers and 1.45 tractor. Conversion of absolute numbers into common unit of power (H.P.) can give a feel of this change.

Table I shows the results. The contribution of tractors in the total mobile farm power has steadily grown. Starting from 4 per cent in 1961, it has reached a level of 23 per cent by 1977. The contribution of cattle has suffered a decline, though it still remains dominant. It may be noted in passing that the contribution of manpower has not decreased. By 1977 the total mobile farm power from all the three sources in Punjab was 0.674 H.P./ha. of which the tractor component was dominant, 71 per cent. On all-India level by the same year the tractor component in the total mobile farm power was 17 per cent. Gujarat, thus, is much below Punjab but is above the national level.

Table II shows the mobile farm power situation as it existed in 1977 in various districts of Gujarat. Gandhinagar is rather a small district. Barring it, Kheda is the one with the largest component of tractor power, 48 per cent.

TABLE I—CHANGES IN MOBILE FARM POWER SOURCE IN GUJARAT

Source	1961	1966	1972	1977
1. Draft animals				
Number (million) ..	3·03	3·05	3·06	2·87
Equivalent H.P. ('000) ..	1515	1525	1530	1435
	(89%)	(85%)	(77%)	(66%)
2. Manual labour				
Number (million) ..	1·25	1·54	1·89	2·41
Equivalent H.P. ('000) ..	125	154	189	241
	(7%)	(9%)	(9%)	(11%)
3. Tractors				
Number	1,999	3,248	7,858	14,517
Equivalent H.P. ('000) ..	70	114	275	508
	(4%)	(6%)	(14%)	(23%)
Total mobile farm power (H.P./ha.)	0·176	0·185	0·204	0·229

Figures in parentheses are percentages with respect to the total mobile farm power. Power equivalent: 0·5 H.P./cattle ; 0·1 H.P./man; tractors 35 H.P. which is the most common.

TABLE II—DISTRICTWISE MOBILE FARM POWER SITUATION IN GUJARAT (1977)

(H.P./ha.)

	District	Cattle	Tractor	Manual	Total	Share of tractors (per cent)
1.	Gandhinagar ..	0·116	0·230	0·046	0·392	59
2.	Kheda	0·145	0·172	0·042	0·359	48
3.	Ahmedabad ..	0·095	0·074	0·030	0·199	37
4.	Surat	0·206	0·150	0·063	0·419	36
5.	Mehsana	0·116	0·081	0·032	0·229	35
6.	Amreli	0·119	0·063	0·013	0·195	32
7 (*a*)	Valsad	0·283	0·091	0·059	0·433	21
7 (*b*)	Rajkot	0·116	0·034	0·014	0·164	21
8.	Bhavnagar	0·113	0·033	0·016	0·162	20
9 (*a*)	Bharuch	0·141	0·042	0·051	0·234	18
9 (*b*)	Junagadh	0·168	0·042	0·022	0·232	18
9 (*c*)	Sabarkantha	0·231	0·055	0·021	0·307	18
9 (*d*)	Surendranagar ..	0·073	0·020	0·017	0·110	18
10.	Vadodara	0·180	0·045	0·041	0·266	17
11.	Banaskantha	0·123	0·023	0·013	0·159	15
12.	Kutch	0·057	0·012	0·016	0·085	14
13.	Jamnagar	0·118	0·017	0·011	0·146	12
	Panchmahals ..	0·458	0·008	0·015	0·481	Neg.
	Dangs	0·221	0·001	0·016	0·238	Neg.
	State	0·151	0·053	0·25	0·229	23

Source: Compiled from Livestock Census, 1977.

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Source: Compiled from Livestock Census, 1977.

Those with tractor component between 30 and 40 per cent are Ahmedabad, Surat, Mehsana and Amreli. Those from 20 to 30 per cent are Valsad, Rajkot and Bhavnagar. Eight districts have between 10-20 per cent, *i.e.*, less than or nearly upto the national average.

In Panchmahals and Dangs the presence of tractor is negligible. Thus ten out of 19 disricts of Gujarat are below or upto the national average.

It can be noted in passing that the presence of draft cattle per unit area cultivated is highest and perhaps excessive in Panchmahals. It is also rather high in three other districts, Dangs, Valsad and Sabarkantha.

The variation in the degree of tractor power among the districts is substantial. We shall see later that the uses to which the tractor is put so far are not crop specific operations but common to many crops. At this stage therefore difference in crop mix will not be the major explanatory variable. Perhaps the availability of water stimulates mechanization.

Table III shows the estimated number of draft cattle according to the size of holding in Gujarat. It is seen that the draft cattle holding per household is less than a pair right upto the 10 ha. size-group. This means, that a certain proportion of farmers in each of these categories are short of draft cattle to some extent and meet their requirement by borrowing, lending draft cattle and tractors.

TABLE III—ESTIMATED NUMBER OF CATTLE PER HOUSEHOLD IN GUJARAT (1977)

Size class of holding (ha.)	Average size (ha.)	Cattle per household
Below 1·00	0·50	0·60
1·00-1·99	1·46	1·13
2·00-3·99	2·87	1·24
4·00-9·99	6·20	1·73
10·0 and above	14·91	2·26

Source: Report on Agricultural Census, Gujarat State 1976-77, Tables of Input Survey, Vol. III, Part I, Government of Gujarat, Revenue Department, March 1982.

The problem in this regard for the first three categories, *i.e.*, marginal and small farmers, may be more acute. The ownership of tractor individually and jointly does not go below 4 to 10 ha. category in any significant measure. A sample survey [Sharan and Krishna (1974)] indicated in the mid-seventies that tractor owners widely practised custom hiring and that the majority of the customers were from the smaller category of cultivators.

(*b*) *Stationary Power Unit for Specific Operations*

Such equipments as have their own power unit are used for specific operations. Table IV shows the important self-powered equipments in Gujarat. Water lifting is the operation where mechanization began early and took

TABLE IV—EQUIPMENT WITH SELF-CONTAINED POWER UNITS IN GUJARAT

Item	1961	1966	1972	1977
1. Irrigation pumpsets (Nos.)				
Diesel oil	44,982	112,428	3,71,114	4,22,050
Electric	6,225	14,729	48,377	79,414
Total	51,207	1,25,157	4,19,491	5,01,464
2. Threshers (Nos.)				
Wheat threshers	—	—	5,831	15,192
Threshers for other crops ..	—	—	1,451	3,872

Source: Livestock Census.

place rapidly. The bullock water lifts (Persian wheels, *khos*) are now rarely used, having been replaced by motorised pumps [Patel (1980)].

As distinct from tractors, the use of pumpset is more widespread and is available to smaller category of cultivators also. Table V shows the estimated number of sets in possession of various categories of farmers. It is seen that joint ownership has facilitated substantially the spread of pumpsets.

TABLE V—HOLDING SIZEWISE OWNERSHIP OF PUMPSETS IN GUJARAT (1977)

Size class (ha.)	Pumpsets owned ('000)		
	Individually	Jointly	Total
Below 1·00	22·9 (56%)	17·8 (44%)	40·7 (100%)
1·00-1·99	41·8 (60%)	28·2 (40%)	70·0 (100%)
2·00-3·99	140·1 (80%)	34·4 (20%)	174·5 (100%)
4·00-9·99	254·2 (85%)	46·2 (15%)	300·4 (100%)
10·0 and above	98·1 (93%)	7·6 (7%)	105·7 (100%)
All sizes	557·1 (81%)	134·2 (19%)	691·3 (100%)

Source: Report on Agricultural Census, Gujarat State 1976-77, *op. cit.*

Nearly one-fifth of the total number of sets in operation are estimated to be jointly owned. Among the lowest category of farmers this proportion is 44 per cent. Mechanization of water lifting has enabled the farmers to tap groundwater in larger quantity and from greater depths. This has eased one of the most severe constraints on Gujarat agriculture—the water scarcity, and has contributed to stability and growth in yields.

Stationary threshers, particularly for wheat have grown in the last decade. The total wheat grown in the State usually is only about 0.6 million ha. There are three systems of threshing: bullock treading, tractor treading and by threshers. All these systems are still prevalent. On the basis of the working capacity of nearly 15,000 wheat threshers, it can be said that about 30 per cent of the wheat is threshed by the threshers. The use of threshers for other crops is much less, though growing. Tractor treading is not an efficient use of tractors. It is desirable therefore to see that the use of threshers including those that can be operated from tractor PTO, should be promoted.

Growth in Implement Use

Change in the implements is the second index of mechanization. The change becomes more vigorous when a new power unit becomes available. In our case the newest power unit is the tractor. Power tillers have not done well in Gujarat and their presence is negligible.

(*a*) *Tractor Drawn Implements*

Table VI shows the growth of important tractor driven equipments. A tractor purchaser does not acquire all attachments at once. Clearly, the most popular attachments are the cultivators and trailers, followed by levellers and scrappers. The cultivators are used for primary and secondary tillage, trailers for haulage. Levellers and scrappers are used for land shap-

TABLE VI—TRACTOR-BASED EQUIPMENT IN GUJARAT

(*Numbers per 100 tractors*)

Item	1972	1977
Tractor equipment		
(*a*) Cultivators	68	74
(*b*) Levellers and scrappers	23	28
(*c*) Seed drills	41	15
(*d*) Trailers	47	69
(*e*) Sprayers and dusters	7·4	3·6

ing. The number of cultivators, trailers and levellers and scrappers has registered an increase between 1972-77. The same is not true of seed drills, sprayers and dusters. Table VII shows the districtwise data on tractor drawn cultivators and trailers. The general pattern is similar.

The decline in the seed drills may mean that the farmers made efforts to bring these into use, but it did not gain momentum. As we shall see later, the seed drills are still scarcely marketed in Gujarat.

Taking the presence and growth of equipment, the three operations which appear to have been mechanized so far are tillage, land shaping and haulage. The basic features of these are common to all crops. Further, these are all bullock powered operations.

TABLE VII—DISTRICTWISE DATA ON IMPORTANT TRACTOR DRAWN IMPLEMENTS IN GUJARAT

(Numbers per 100 tractors)

District	Cultivators	Trailers
Gandhinagar	75	74
Kheda	78	81
Surat	66	74
Valsad	53	53
Mehsana	42	75
Ahmedabad	77	71
Amreli	76	90
Sabarkantha	109	62
Vadodara	65	66
Junagadh	86	76
Bharuch	60	56
Rajkot	70	54
Bhavnagar	81	55
Banaskantha	66	52
Surendranagar	67	72
Jamnagar	67	79
Kutch	70	48
Panchmahals	Neg.	—
Dangs	Neg.	—
Gujarat	74	69

Source: Compiled from Livestock Census.

It also implies, however, that the annual use of tractor on all the three major operations combined will not be sufficient to fully utilize the tractor. The farmers do try to make up for it to an extent by renting out the tractor. Since the agricultural operations are time critical, renting out the tractor can increase utilization only to a limited extent without jeopardising the owners own farming. There is thus need to extend its usuage to other operations. Again, the farmers do try to do this by using tractor for puddling and threshing, even without a proper equipment for these operations.

Availability of specialised equipment may be a problem. In order to verify the findings and understand the constraints, information was gathered on the manufacture of tractor drawn implements in Gujarat. The information on the type of equipment manufactured in the Western region, particularly Gujarat has recently been collected by Gujarat Chapter of Indian Society of Agricultural Engineers and published in the form of a directory (1983). There are altogether 52 manufacturers in the Western region who make tractor mounted equipment. Out of these, 31 are in Gujarat. Of these 31, only 25 have clearly specified the equipment they make. Out of these 25, ten are engaged in making tillage equipment and seven in making trailers. Only one of the manufacturers is engaged in making sowing and planting equipment. There is thus likely to be a problem of availability of this equipment. It needs to be probed as to why the supply system is ignoring such equipment as drills and planters, and plant protection equipment. Is it because of lack of demand or lack of appropriate designs? And if it is due

to lack of demand, is it due to the lack of awareness among the farmers of the usefulness of such equipment or the price of these ? The coverage of the tractor drills and planters usually ranges from 4 to 6 ha./day. This implies that the use of such equipments even on large farms will be very limited, usually one to two days in a season. It will be necessary, therefore, that either the price of equipment be low or it be made available on rental basis. These can also be owned and used jointly.

(*b*) *Animal/Man Operated Implements*

Table VIII shows the number of implements per 100 pairs of draft animals over the years. It is seen that the complement of implements that go with bullocks is wider than was the case with tractors. Ploughs, blade harrows which are present in large numbers are tillage and inter-culture equipment. It is followed by the seeding attachments. This indicates that most of the sowing is done by bullocks. The number of carts is high, and has marginally increased.

TABLE VIII—ANIMAL-DRIVEN EQUIPMENT IN GUJARAT

(*Number per 100 pairs of draft animals*)

Item	1961	1966	1972	1977
Implement				
(*a*) All ploughs	103	102	110	111
Iron ploughs*	6·7	8·8	12·7	14·4
(% of total)	(7)	(9)	(12)	(13)
(*b*) Blade harrows	—	—	68	68
(*c*) Wetland puddlers	—	—	9·4	9
(*d*) Earth levellers	—	—	14	11·6
(*e*) Seed drills**	—	12	43	43
(*f*) Persian wheels	1	0·8	0·4	0·2
(*g*) Carts	46	47	53	52
(*h*) Oil crushers	0·3	0·2	0·1	0·06
(*i*) Cane crushers	0·3	0·2	0·3	0·2

Source: Livestock Census.

*The soil turning ploughs, the mould boards are referred to as the iron ploughs in the Census.

**These do not meter seeds, and do not enable placement of fertilizer, essentially these are seeding attachment to a plough.

Among the tillage and land shaping implements that have suffered a decline are wetland puddlers and the earth levellers. It may be the result of the fact that their counterparts driven by tractors have increased. It is now common to see the tractor being used for puddling. There are two methods usually observed. First, the tractors are fitted with cage wheels and just the ordinary cultivator is used to puddle the fields. Second, a trailed rotavator is attached to the tractor.

The use of bullocks, it may be noted, has reduced drastically or discontinued altogether in such operations as water lifting, oil and cane crushing. Bullocks continue to be used for threshing, but since it is commonly done

without a thresher, it is not reported. One also does come across Olpad thresher in the field.

The Livestock Census and also the Agricultural Census leave out the manual tools. This may be because the manual tools are not standardised, and are of low cost. There are many operations which are done manually like the inter-culture, harvesting, and winnowing of most crops. Cotton picking, cotton stalk pulling, groundnut digging are done almost entirely manually. In groundnut digging bullocks are also employed. Plant protection appliances are largely manually carried or operated. The Census does report significant increase in the number of manual sprayers and dusters from 35,932 in 1972 to more than twice, 84,549 in 1977.

On the basis of the above findings, a broad outline can be drawn of operationwise state of mechanization for the major crops of Gujarat. The ten major crops of Gujarat are cotton, groundnut, bajra, jowar, wheat, rice, maize, tobacco, sesamum, rapeseed and mustard. Preparatory tillage, land shaping, water lifting and haulage are substantially mechanized in almost all cases. The operations which are dominantly done manually or by bullocks are sowing and planting, manuring and fertilizing, plant protection and harvesting. The use of tractor and threshers for threshing is increasing, particularly in wheat. Winnowing is done manually by using winnowing fan.

In those districts where tractorisation has progressed to a significant level—Kheda, Ahmedabad, Mehsana, Surat and Amreli—it will now be necessary to identify and overcome the constraints on the supply side of special equipments to go with the tractor. Among these will be multi-crop seed and fertilizer drill or planters which can handle cotton, groundnut and maize, on the one hand, and sorghum, wheat and millets, on the other. The seed and fertilizer drills and planters must be given high priority since the effectiveness of fertilizer depends on precise placement in relation to seed and plant. Mechanizing inter-cultural operations in some cases like cotton, will require high clearance tractors. There will be need for multi-crop threshers either of stationary type or PTO driven. In the case of rice, it will be necessary to have appropriate puddlers, both bullock driven and tractor driven.

SUMMARY AND CONCLUSIONS

A review of the status and nature of mechanization was done on the basis of Livestock and Agricultural Census data on equipment. The extent of tractor contribution to mobile farm power was determined. The types of and growth in tractor driven implements were identified. Where possible, districtwise distribution and the ownership pattern have been indicated. On the basis of the above, the following conclusions can be drawn.

(*a*) The pace of mechanization in Gujarat judged by the contribution of tractors to the mobile farm power has been higher than the national average, but is still much below that of Punjab. The proportion of tractor power in the total mobile farm power is 23 per cent in Gujarat.

(*b*) There is considerable variation in the degree of tractorisation in the districts of Gujarat. More than half the districts are below or only upto the national average in terms of the contribution of tractors to mobile farm power.

(*c*) The variation in the districts is in the degree rather than in the type of mechanization. The type of mechanization so far in Gujarat has been such as to reduce the use of bullocks and not that of manual labour. Mechanization of water lifting began early and progressed rapidly. The use of tractors followed. The major operations in which the use of tractor has spread are bullock powered just as the water lifting was.

(*d*) On the whole, however, the bullocks still retain dominant position as source of farm power. And in many critical operations like sowing, farmers still have to depend on them. In transport also the bullocks have retained their importance.

Similarly, the role of manual labour has not diminished in inter-culture, plant protection, fertilizer application, and harvesting. Since the bullock-man system is likely to co-exist with tractors for quite some time to come, there is need to effect improvement in the bullock-man operated equipment. The priority equipment will be seed drills, planters, puddlers, groundnut digger, decorticators, etc.

At the same time, efforts should be made to see that this period of co-existence is reduced. For the cost of maintenance of dual sources of farm power is likely to be higher than that one provided it permits undertaking the required range of operations.

(*e*) The use of tractors is yet confined to three operations—preparatory tillage, land shaping and haulage. Besides being all bullock operations, these are common to all crops. It is perhaps rational on the part of the farmers to go for equipment that is of multi-crop use. On the other hand, the total usage of tractor per year on all the three operations combined will fall short of the annual tractor capacity and thus make for under-utilization of tractors. Custom hiring which is widely practised, should be encouraged further. But this alone will not solve the problem of under-utilization. The real solution lies in development, marketing and popularisation of equipment appropriate for crop specific operations. It is understood that this will mean slightly greater specialisation than has been the case so far.

The priority equipment are multi-crop seed-cum-fertilizer drills, planters, groundnut digger, puddler, PTO driven threshers, pumps, plant protection appliances, etc.

(*f*) An interesting feature of Gujarat farming is the joint ownership and use of power units. This is found to be significant in the case of pumpsets and to a lesser extent in tractors. Borrowing and lending of bullocks are also widely prevalent. This is a very positive feature. Considering the smallness of (even the large) holdings the only way to facilitate the spread of equipment and machinery among the lower category of farmers is to promote and facilitate the above tendency. Gujarat farmers seem to co-operate better. This

attribute should be used to promote the use of specialised equipment mentioned above, since its use on individual basis only may not be economic.

(*g*) In time to come, Gujarat will need to tackle the problem of horizontal and vertical spread of mechanization within districts and narrowing the gap between the districts. The horizontal spread will mean covering more operations which in turn will mean developing equipment for major crops of the State and suited to local conditions. Narrowing the inter-district difference will require development of equipment suited to rainfed and dry areas. The vertical spread will mean strengthening the organizations that undertake joint use of equipment so as to increase their accessibility to the smaller category of farmers.

(*h*) The supply system in this region also deserves attention. There is evidence that it is concentrating on such equipments as tillage and threshing and transport. The interaction of supply system with R & D centres needs to be made more active in order that suitable designs of drills, planters and other equipments are evolved, manufactured and marketed.

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