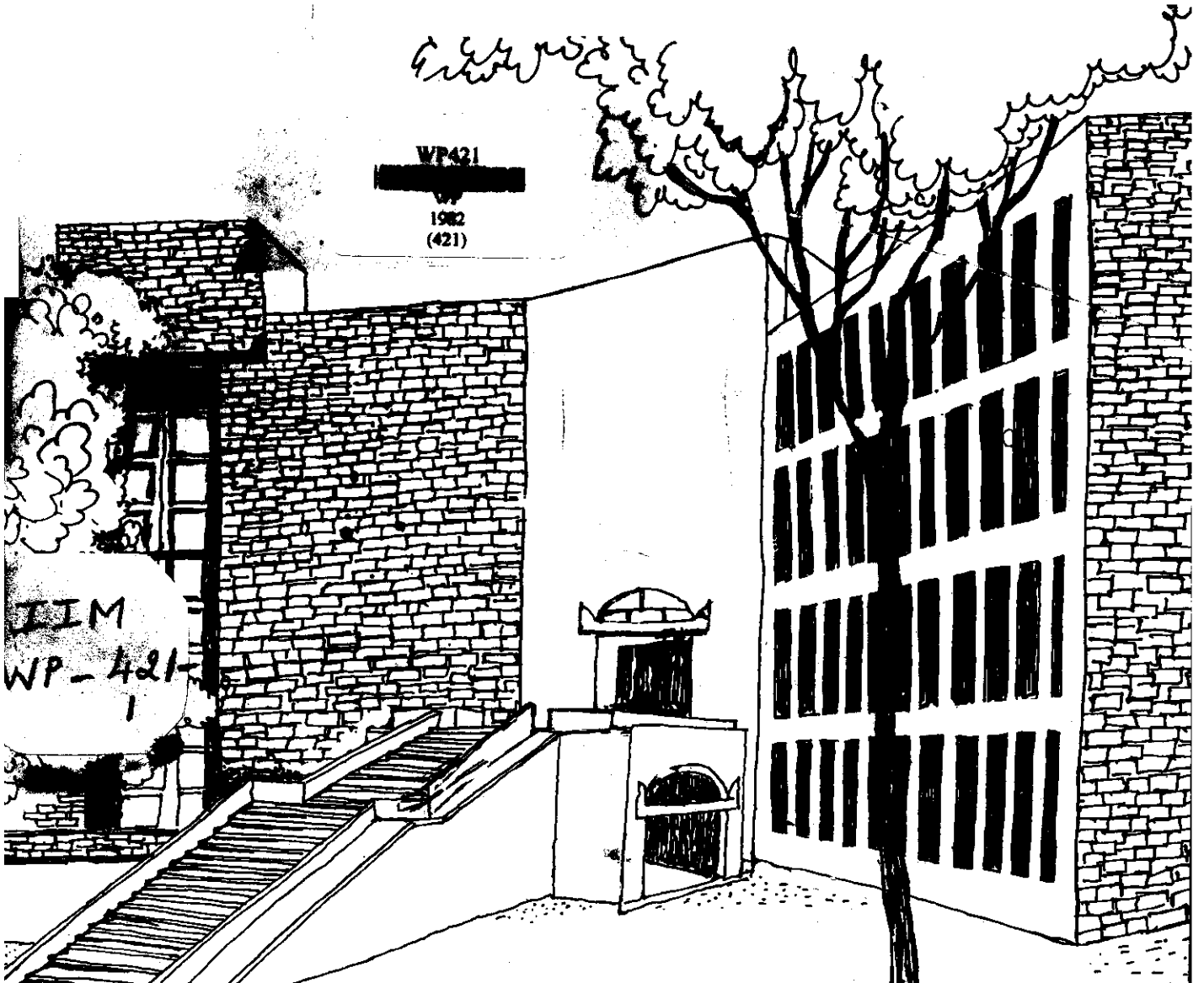


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# Working Paper



AGRICULTURAL MECHANIZATION IN GUJARAT

By

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# AGRICULTURAL MECHANIZATION IN GUJARAT

GIRJA SHARAN

## 1. Introductory

Gujarat province lies in the central region of West-coast of India. Its total geographical area is 195,984 sq.km., of which the forest constitutes 8%. The total area under cultivation in the province is approximately 10 m.hect. There are nearly 2.4 m. operational holdings of various sizes, the average size being 4.11 hect. (Table A-1). As of the mid-seventies, the area irrigated was 15% of the land under cultivation.

Recent cultivation data shows about half the cultivated area (49.7%) is devoted to foodgrains; of the remaining, cotton was grown in 16.3% of the area, ground nut in 20.3%. Tobacco, sugarcane are other noteworthy crops. Among the food grains, bajara (millet) jowar (Sorghum Vulgare) wheat, maize are important followed by pulses. There are two major cropping seasons, the kharif extending from May to October, and the rabi from October to April. Summer cropping is done to a very limited extent.

In this paper, attempt is made to outline the nature of the agricultural mechanization, that is taking place in Gujarat. The analysis is based chiefly on the data collected in the course of livestock census which are carried out at the interval of 5 years, by government.

Since the constitution of Gujarat as an independent province in 1956, there have been five such censuses, (1956, 61, 66, 72 and 77) of which the results are available. Some data pertaining to the year 1951 is also available, having been compiled for Gujarat region, from the total Bombay province data, of which Gujarat was then a part. Thus, the data on the number of important, although a limited set of agro-machinery is available for six points of time, between 1951-77, at 5 year interval. Since this is the only source of systematically collected data over time, it has its usefulness. On the other hand, there are also certain feature that restrict its usefulness in fully understanding the process of mechanization.

We shall presently discuss these features. But first it is necessary to state as to what is meant by mechanization.

In agriculture, mechanization occurs in stages; each stage being characterized by a degree of mechanization. It is customary to represent mechanization in agriculture by the growth of certain important prime-movers like the tractor or sophisticated machinery like the self-propelled combines. In agriculture, mechanization often occurs in stages, with partial changes in tools and sources of energy. For the purpose of this paper, the mechanization will be divided into the following categories:

The first kind of situation encountered in agriculture is one where man acts as the source of energy and he uses his body parts (hands, feet, etc.) as tools to perform the tasks. This is non-mechanized situation. The examples: hand picking of Cotton, manual milking of cow, carrying head loads of farm produce, hand cleaning and grading of seeds, etc.

The second type is where man continues to be the prime mover, but employs tools instead of his body parts to perform the task. For example trolley to transport farm produce, use of hand rocked sieve to clean seeds, inter-cultural operations with hand hoe, use of sling to scare away bird pests, etc. This situation represents beginning of mechanization. More and more sophisticated and a wider range of manual tools may be produced to perform complicated and larger number of tasks.

The third type of mechanization is where man employs tools as well as an external prime mover to operate the tools. The man retains the logistical functions of guiding the power unit and tools. For example, walking behind a bullock driven plough, steering a tractor on which is mounted agricultural equipment, driving a bullock cart, etc. This situation can be divided into two, one in which power source is animate and the second, where it is inanimate.

The fourth, and perhaps, the highest degree of mechanization is 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 based irrigation system can be an example.

In Gujarat, (as indeed in India) the examples of the fourth type are not found. In Gujarat (and India) agricultural mechanization scene is characterised by simultaneous existence of the first type, the second type; and a growing extent of the third type of mechanization. The examples of the first type are also becoming uncommon.

## 2. Farm Machinery in Gujarat

Tables (A2-A4) of the appendix give the census results. The results of the first three census have been presented in table (A-2) since these covered the same set of agro-machinery. The list of equipment covered in the subsequent census has been changing, therefore, the results are presented separately (Table A3 & A4). Some limitations of the census data should be kept in mind.

First, the equipments that are enumerated are not the only equipment in use. Generally, the number of equipment in use is much larger. It is not clear as to what criteria is used to exclude or include a particular equipment in the census. Perhaps, equipment of higher capital value are more likely to be included. Secondly, the census data does not record specifications such as power rating, size, etc. of equipment that do get enumerated. In certain cases such as the ploughs it will not create much problem. However, in cases like the tractor, lack of size specifications will seriously limit the comparability between the data of one census from another. For instance, in earlier times, the size range of tractors available in India was very limited. Lately there are over 18 sizes and 28 models being manufactured and marketed. Thirdly, a rather conspicuous, aspect is that manually operated agricultural equipment which are still extensively used, are all but ignored by the livestock census. With the exception of sprayers and dusters, a large proportion of which are hand operated, the hand tools are not enumerated. It is known for instance that a very large number of hand driven chaff cutters of several types are in use in this province almost the entire harvesting of food grain crops, even sugarcane, etc. is done with various types of sickles and cutters, hand operated winnovers are widely used as also the hand operated interculture equipment such as Khurpi, hoes and rakes. Yet all these find no place in the census. This is a serious gap. Recent discussion with the census officials revealed however, that some of the shortcomings are being overcome now, specifications will be recorded, more equipment is to be added to the list.

Besides the livestock census, there are some additional sources of information about implements. One such is the sample survey carried out alongwith agricultural census in 1976-77. Table (A-5) of appendix gives the details. There again the number of implements covered are limited; the chaff cutter is the only additional item found. However, information on ownership of equipment according to size of land holdings is useful. We shall return to it later.

Apart from the government the research institutions, academic and industrial organizations also undertake specific studies occasionally. We shall make use of some of the relevant studies.

## 2.1 Farm Power in Gujarat

The direct energy needed for various agricultural operation is provided by three sources draft animals, humans and mechanical units such as tractors, power tillers, stationary engines, electric motors, etc. For the purpose of analysis these are divided into two categories, first the mobile prime movers, and second the stationary prime movers. The mobile prime movers are draft animals, humans, tractors and power tillers. The stationary ones are engines, motors, and others as engine-run power threshers, etc.

As of 1977, in the province as a whole, the draft cattle density was 7 h. of cropped acreage per pair. The density of tractors was smaller by orders of magnitude: one tractor for every 720 h. of cropped acreage. According to the Regional Transport Office, Ahmedabad, the total number of tractors registered by 1980 in Gujarat had risen to 34,000. The tractor density by 1980, therefore, had reached about 308 h. per tractor. As compared to this, even in mid-seventies the tractor density in Punjab, perhaps, most highly mechanized state in India, was one tractor for every 115 h. of cropped acreage. In mid-seventies, the tractor density for India as a whole was 595 h. per tractor.

The total power through the three mobile prime movers, animals, human and tractors, present on Gujarat farms in 1977 stood at 0.337 hp/hc. (Table 1). If the power available through engines and electric motors used in pump sets is added, magnitude increases appreciably to 0.59 hp/hect. Again this is much lower compared to what obtained in Punjab in the mid seventies, 0.58 of hp/hect. for the mobile prime movers, and 1.10 hp/hect. when irrigation power is included. In Gujarat, the increase in the power has occurred chiefly due to very large increase in the number of engine/motor driven

Table (1):- FARM POWER AVAILABLE FROM  
MOBILE PRIME MOVERS AND MAJOR STATIONARY  
SOURCES IN GUJARAT

( hp. per hect. cropped area )

Source	1961	1966	1972	1977
1. <u>Mobile</u>				
(a) From Draft Animals <sup>1</sup>	0.155	0.152	0.143	0.138
(b) Manual Labourers	0.124	0.13	0.18	0.198
(c) Tractors	0.0002	0.0003	0.0009	0.0014
(d) Total	0.279	0.28	0.32	0.337
2. From electric motors and engines	0.026	0.062	0.213	0.25
3. Total 1(d) + (2)	0.30	0.34	0.53	0.59

For conversion into power units, draft animals were taken to produce 1 hp. per pair, manual labor 0.1 hp/ person. Average size of tractor 30 hp. engines and motors of 5 hp. each on average, were assumed.

pumpsets of about 5 hp. each. The increase in these has also been much more rapid than the tractors and had set-in earlier, in the early sixties itself (Fig.1). By 1977 there was one pumpset for every 21 h. of cropped acreate. The farm power available on farms is also increasing through threshers and other power based machinery whose numbers are growing.

While using the index like power available per unit area, the following should be kept in mind. Strictly speaking what is more important is power used on the farm, that is energy expended on farm activities. In order to convert the above index into energy the amount of time for which various prime movers are used should be taken into account. The time for which prime movers are used will vary from region to region depending on the nature of crops, etc. Further more, not all the farm activities require same amount of power. This is true for the tasks performed by any prime mover, and can be particularly variable in case of animate sources.

Nag et al<sup>2</sup> have shown that energy expended by an agricultural worker in most leisurely activity like counting grains is 4.49 KJ/min. Whereas for the most strenuous one of bund trimming, for instance, it was nearly 6.5 times higher, 29.54 KJ/min. A large majority of manual farm work however, required 9 to 18 KJ/min. of energy, which works out to nearly, 0.3 hp. of the average is considered 14 KJ/min. Similarly, stout<sup>3</sup> has compiled energy expended by animals, on various types of farm activities. As expected, the energy expended and power output of animals varied with breed and activity. The power output varied around 1 hp. from a low of 0.56 to as high as 1.6.

The point is that the index like hp/hect. should be used only for a very approximate comparisons of status of mechanization. It is in the nature of what can be called a 'ball park' estimate. More precise index must be based on energy (not power) and it should be compiled on activity basis.



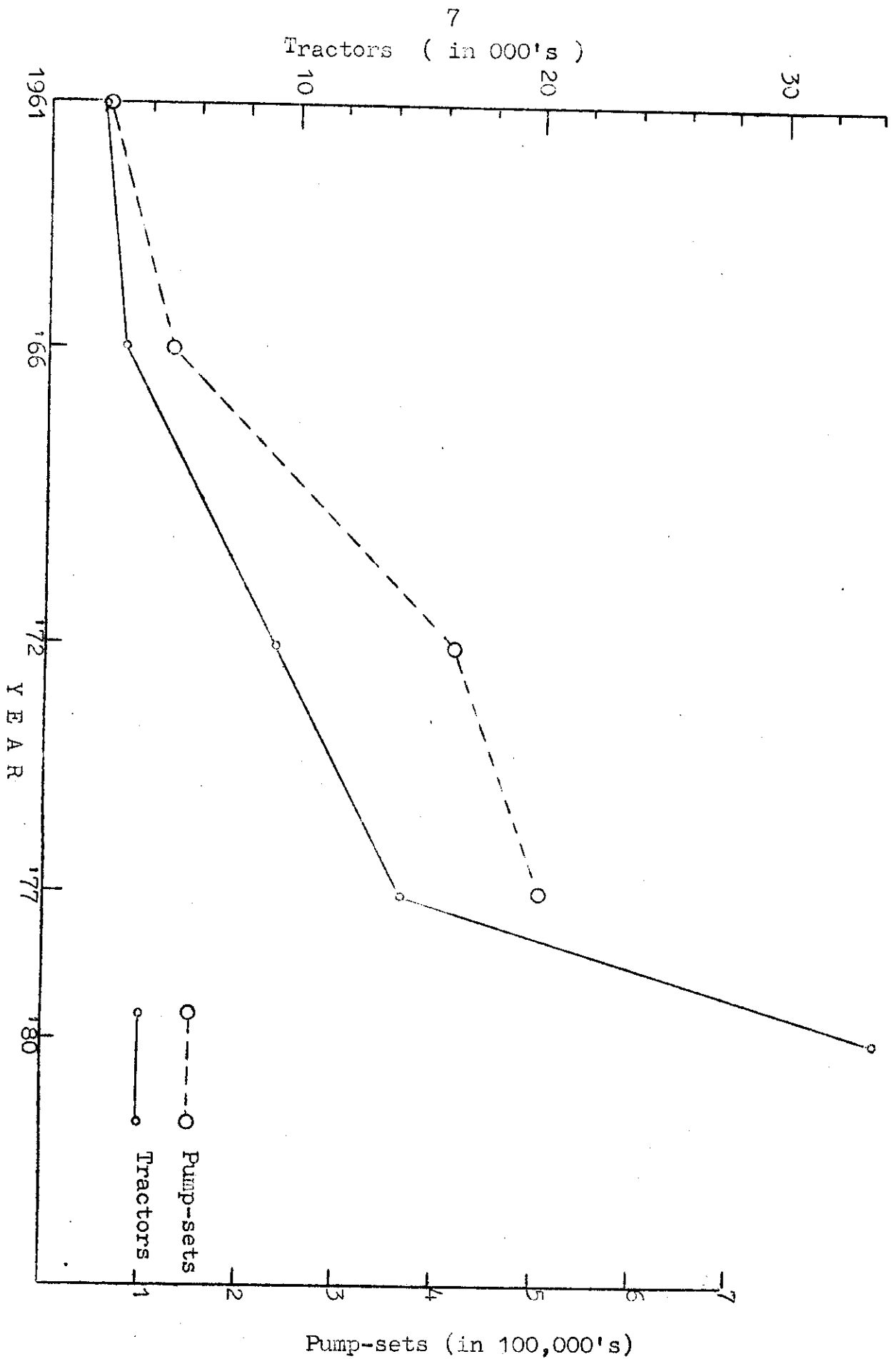


Fig. (1) Tractors and Pumpsets in Gujarat.

## 2.2 Bullock Based Equipment and Activities

It was stated earlier that the draft animal density according to last census works out to be one pair for nearly every 7 h. of cropped acreage. Most of bullock driven implements are drawn by a pair. In order to examine the implement situation, therefore, we have used pair of draft animals as the reference. Table (2) shows the number of implements per 100 pairs of draft animals over the year. The most numerous implement is the plough whose number has over the years increased from 97 to 111 per 100 pairs of draft animals. Majority of these ploughs are of wooden beam, frame and iron share. The proportion of 'iron plough' which are really mould-board type, has steadily increased. These new constitute over 14% of the ploughs.

The number of bullock operated oil crushers and the persian wheels (used for water lifting from wells) has suffered a steady decline (fig.2). By now these equipments are rarely seen. The function of persian wheel and other such devices has been taken over by pump sets mentioned earlier. The oil crushing is now done by mills on power equipment and lately through solvent extraction process. In case of sugarcane crushing, where as the proportion of power crushers in 1956 was only 33% of the total, it had risen to 49% by 1977. It is quite likely that bullock operated cane crushers have also by now yielded totally to power crushing, even on the farms.

The number of carts per 100 pair of animals has not declined, indeed has increased from 47 to 52 between 1956-77. This would suggest that use of animals for transport continues to be important. It may even have gained in importance marginally (Fig.3).

Among the implements that have become popular in the last decade, is the seed cum fertilizer drills whose numbers now approach that of the carts.

Among the tillage, interculture and land shaping implements that have suffered a decline are wetland puddlers and to a much greater extent the earth levellers. But, the plough and the blade harrows have retained their very significant place.

The following conclusions will seem to emerge (a) the use of bullocks in water lifting, oil-seed crushing and cane crushing has almost been discontinued. All these being replaced by powered equipment or mills, (b) use of bullocks in a certain tillage and land shaping operations is also being

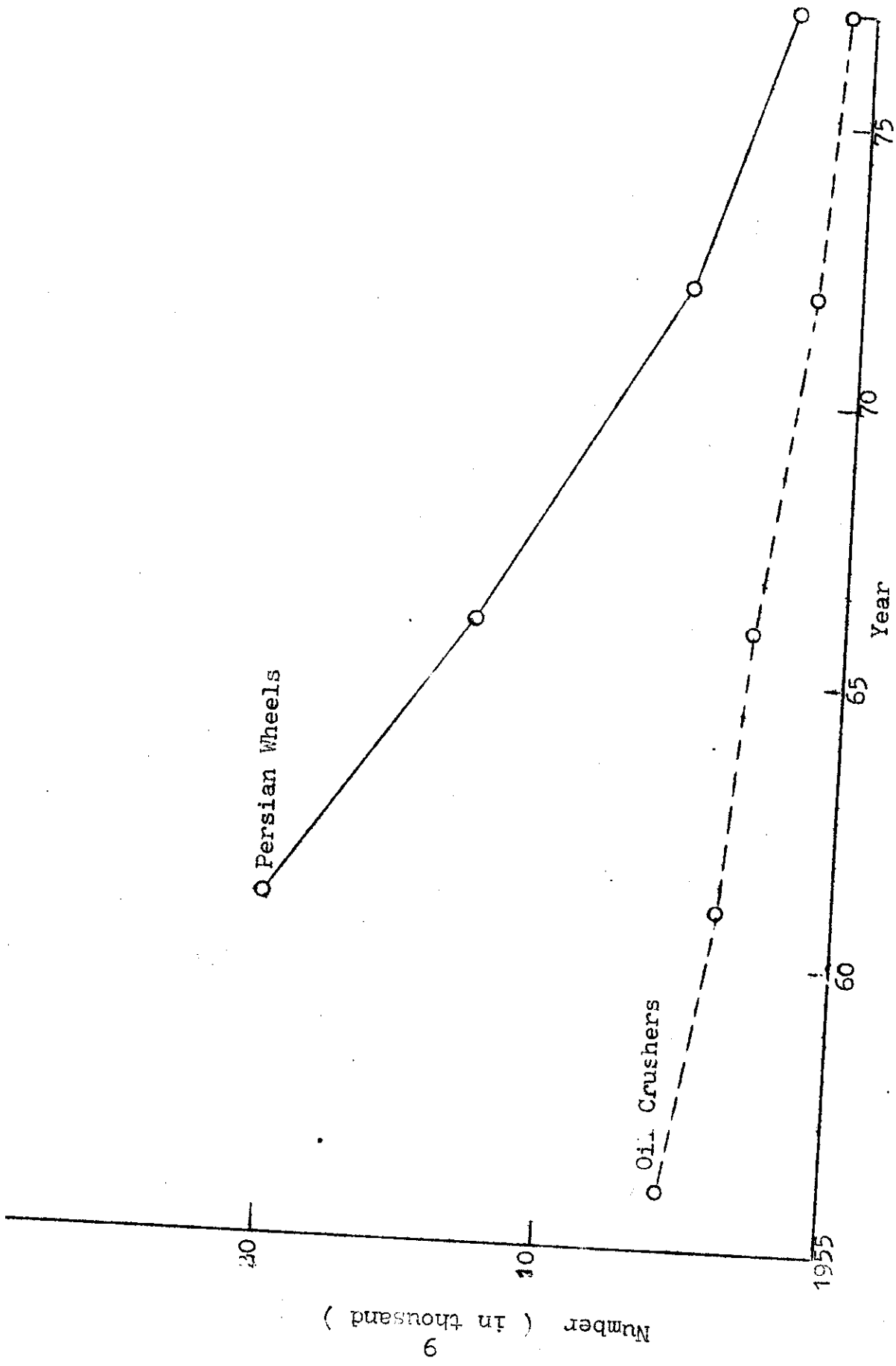


Fig. (2) Persian Wheels and Oil Crushers in Gujarat

Table (2) ANIMAL DRIVEN EQUIPMENT INGUJARAT

( Per 100 pair of draft animals )

Item	1956	1961	1966	1972	1977
1. Draft Animals (million pairs)	1.35	1.51	1.55	1.54	1.45
2. Ploughs (Total)	97	103	102	110	111
(a) Iron ploughs % of total	4	6.7	8.8	12.7	14.4
3. Blade Harrows	-	-	-	68	68
4. Wetland Puddlers	-	-	-	9.4	9
5. Earth levellers	-	-	-	14	11.6
6. Seed drills	-	-	12	43	43
7. Persian wheels	-	1	0.8	0.4	0.2
8. Carts	47	46	47	55	52
9. Oil crushers	0.4	0.3	0.2	0.1	0.06
10. Cane crushers	0.2	0.3	0.2	0.3	0.2

reduced; ploughing and harrowing however, continue to be the most significant areas of bullock use, (c) use of bullocks has grown in sowing operation and in transport. Among the new equipment, as will be seen shortly, are plant protection devices, whose numbers have grown enormously. But as will be seen shortly, these are dominantly, man operated and to a lesser extent, tractor operated ones.

### 2.3 Tractor Based Equipment.

As stated, the density of tractors in Gujarat has been growing, having reached in the late seventies, the level of one tractor per over 300 h. of cropped land. This is much lower than that of Punjab, and only slightly higher than that of India as a whole. Power tillers have not gained a foothold in Gujarat.

Table (3) shows that compared to the bullock based equipment, the number of equipment per 100 tractors are more. That is the tractor as prime mover is usually accompanied by a fuller complement of machinery. The tillage interculture and land shaping equipment has grown in the last decade. It will imply that the use of tractors for tillage and intercultural operations, and land levelling etc has grown. A more dramatic increase, however, was witnessed in the number of trailers. These have grown from 47 to 69 per 100 tractors. Thus, transport of farm produce is being done increasingly by tractor and trailers.

Use of tractors in sowing and in plant protection seems to have suffered a set back, as shown by significant reduction in the number of seed drills and plant protection equipment per 100 tractor.

### 2.4 Manually operated Equipment

It was stated earlier that census has been all but ignoring manual implements. The plant protection equipment, sprayers and dusters, have lately been included in the census list. The number of manually operated sprayers and dusters was recorded to be 35032 in 1972 and 84549 in 1977. Clearly, the plant protection equipment is the new addition to manually operated machinery. It was also seen that during the same period, tractor based plant protection equipment has registered a decline.

Table (3) TRACTOR BASED EQUIPMENT IN GUJARAT

( No. per 100 tractors )

Item	1956	1961	1966	1972	1977
1 (a) Tractors (no.)	819	2002	3189	9531	14517*
(b) Power tillers (no.)	-	-	-	1122	438
2. Tractor & Equipment					
(a) Cultivators	-	-	-	68	74
(b) Levellers, scrappers	-	-	-	23	28
(c) Seed drills	-	-	-	41.5	16.5
(d) Trailers	-	-	-	47	69
(e) Sprayers and dustors	-	-	-	7.4	3.6
(f) Others (unspecified)	-	-	-	-	48.5

\* by 1980 the number had grown to over 34,000

Patel et al<sup>4</sup> who surveyed the use of plant protection equipment in Gujarat have found that these are being used mainly in cotton against boll worms, paddy stem borer, groundnut aphids, wheat stem borer and rust disease, etc.

While other hand tools are not enumerated, their use is wide spread. Harvesting of crops is done almost exclusively by hand tools like sickle, choppers and Khurpa, etc. Neither the tractor nor bullock driven harvestors have gained a place in Gujarat yet.

There is provision for loan and subsidies for purchase of agricultural implements. There are over 60 manufacturers recognized by government for manufacture and sales of small equipment. Among the equipment listed are hand operated chaff cutter, cotton stock puller, hand operated harrow, winnowing fan. This can be taken as indirect evidence of continued use and importance of manually operated tools.

### 2.5 Self-Powered Machinery

Among such equipment as have their own power unit, stationery or mobile, are pumping sets, cane crushers, stationary threshers for wheat and other crops, plant protection equipment (table 4).

Pumps and crushers have been discussed, earlier. Threshers, particularly for wheat crop, have registered a rapid increase in the first half of seventies. To a smaller extent use of stationery threshers is being extended to other crops like paddy etc. Plant protection equipment has also registered almost as rapid increase as the threshers. Harvestors and combiners have not appeared in Gujarat. Thus, while harvesting of crops remains manual, mechanization has set in the post harvest operation like threshing and transport.

### 3. Ownership of Agro-machinery in Gujarat

Table (A-5) of appendix gives the estimated pattern of ownership of a selected set of equipment on the basis of a sample survey conducted by the state government in 1976-77 as part of its agricultural census. In view of the vast number of smaller holdings in Gujarat (as also in India) it becomes important to take this factor into account and take measures so that better equipment is widely available.

Let us examine the case of the plough, a popular equipment those with less than 1 h. of land have only 41 ploughs for each 100 households. The no. of ploughs possessed

Table (4) EQUIPMENT WITH SELF  
CONTAINED POWER UNITS

Item	1956	1961	1966	1972	1977
1. Wheat Thresher (no)	-	-	-	5831	15192
2. Threshers for other crops (no)	-	-	-	1451	3872
3. Sprayers, dusters	-	-	-	4480	15921
4. Cane crushers	1300	2000	2100	2529	2397



increases with size class of holdings, reaching 120 for the households of 10 h. and more. Whether or not it should be taken as an index of disparity needs closer examination. On surface it is. However, for instance, if one assumes that the average size of plot in the first category (1 hec.) is 0.5 hect. there is likely to be a total of 50 h. land per 100 households of this class. Among these there are 41 ploughs, i.e one plough for every 1.2 h. The corresponding value for higher classes will be 2.3, 3.4, 6.6 and 8 h. per plough owned. Looked at this way, the density of ploughs increases as the size decreases. Therefore, even though the smaller farmers have less total number of ploughs, they may not be short of this equipment.

As one moves to more costly equipment, such as sprayers and dusters, chaff cutters, threshers, pumpsets, the disparity is greater. Again, however, the actual deprivation may be, less than the actual disparity in ownership. In case of pumpsets for example the 100 household of lowest category own only three. Which makes it 16 h. per pump set. The corresponding number for higher size groups 2-3.99 h. and 4-9.99 h. are 14 and 19 h. per pump set respectively.

It is only in relation to the tractors, that disparity is greatest and might also mean correspondingly lesser actual accessibility. Naturally this will also extend to tractor based equipment.

There is certain degree of joint ownership of machinery in the state. It is limited however. Whereas, there were 43 ploughs owned individually per 100 households of all sizes, there are 5 that are owned jointly. (Table A-6). That is about 10 per cent of ploughs in use are jointly owned. Much the same holds for carts. The joint ownership does not extend to tractors. Thus, it can be said that accessibility of equipment to small farmers by joint ownership is not present in significant scale. It is limited to traditional equipments and does not extend to expensive modern machinery.

#### 4. Custom Hiring of Agro-machinery in Gujarat.

The government has been aware of the need to cater to agromachinery requirement of small cultivators. Several agro-service centres have been opened in the state as also elsewhere in the country for the purpose of renting tractors and other equipments to small farmers.

Sharan and Krishna<sup>5</sup> conducted a study of government custom hiring centres in Gujarat in 1974. At the time of study the government had only 17 centres operating. There

were plans to increase the number gradually. The size of holdings of the farmers using the services of these centres varied between 2-6 hect. The main operation for which tractors were rented were primary tillage, land shaping and threshing. This corroborates the earlier finding that the tractor usage has been growing in tillage intercultural and land shaping operations.

In addition to the government, the private tractor owners also rent out tractors to other farmers. At the time of above studies, (5,6), in early and mid-seventies the tractor owners typically used tractor for a total of 600-800 hrs. per year. Majority of the owners (87%) reported that of the total annual hours of tractor use, nearly 50% was on the own farm and the rest on rental to others. This shows that custom hiring demand is considerable and if organized on a wide scale, it can be very useful in reaching the modern equipment to small farmers.

##### 5. Process of Mechanization in Gujarat

Even within Gujarat the conditions of farming vary a great deal, soil types, water availability, etc. are different. The north western part, Saurashtra, for instance is dry and water is the major constraint in most part of it. Southern part is cotton growing one. Eastern part again is drought prone. The nature and reasons for mechanization will vary

In broad outline, however, the process can be studied as follows. The mechanization of water lifting was the major element that set in early. This enabled the farmers to extend cultivation as well as intensify it.

Almost simultaneously there was occurring mechanization of post harvest processing of such crops as oilseeds, sugarcane, cotton (ginning). The mechanization of crop-processing, however, was probably the result of industrial entrepreneurs and not so much the farmers themselves.

The expansion of lift irrigation was farmer initiated mechanization and therefore, was a more wide spread one. This opened up the possibility of extensive and intensive cultivation and change of cropping patterns. Consequently the need for tractors to cope with time bound tillage operations increased, leading to acceleration in the growth of tractors in the seventies particularly in latter part of it.

Efficient irrigation required also levelling and land shaping. The levellers and scrappers followed the tillage equipment. Increased harvest meant greater transport requirement. Gradually, as the road transport network expanded in rural areas, number of trailers increased, to meet the growing transport requirement. Figure (3) shows steep rise in trailers in the seventies. The transport by bullock carts has also increased during this period.

Land levellers and scrappers drawn by tractors show gradual increase in number (fig.3). In the same period the bullock operated levellers and scrapper show small, but gradual decline. In the course of study of custom hiring centres (5) it was observed that land levelling was one of the important operations for which tractors were hired by the farmers.

Sowing and fertilizer application is a sphere in which the bullock drawn equipment has gained ground. The tractor operated drills have reduced in number significantly between 1972-77. Sowing is a time sensitive operation. Also, the value of precision placement of seed and fertilizer is now widely known. The reason for lack of growth in the tractor operated drills therefore, most likely is lack of suitable designs of equipment. There is need to vigorously pursue the design and development of planters for ground nut, cotton, etc. and drills for other food grain crops in Gujarat.

The power based or tractor mounted harvesting equipment has not appeared in Gujarat yet. These operations are done through manually operated tools.

Among the post harvest operations, it is the threshing that is now being mechanized. Traditionally, threshing of food grains was done by laying the crop on a threshing floor and driving bullocks over it until grains separated. It was later winnowed with the help of natural wind or hand operated winnowing fans. Ground-nut shelling was still done manually.

One of the popular ways of threshing food grains crops now is to have the tractor run over the harvest on the threshing floor instead of the bullocks, the rest of the operations remaining the same. This does not require any equipment and is faster than the bullocks. The stationary threshers for wheat, paddy and other crops are now being used in Gujarat on an increasing scale. Their total number, however, still remains small. There are efforts also now to design and popularise ground-nut decorticators (8).

The general crop cycle can be divided into the following phases. First, the seed-bed preparation, consisting of primary tillage operations, plowing, harrowing, levelling, etc. The

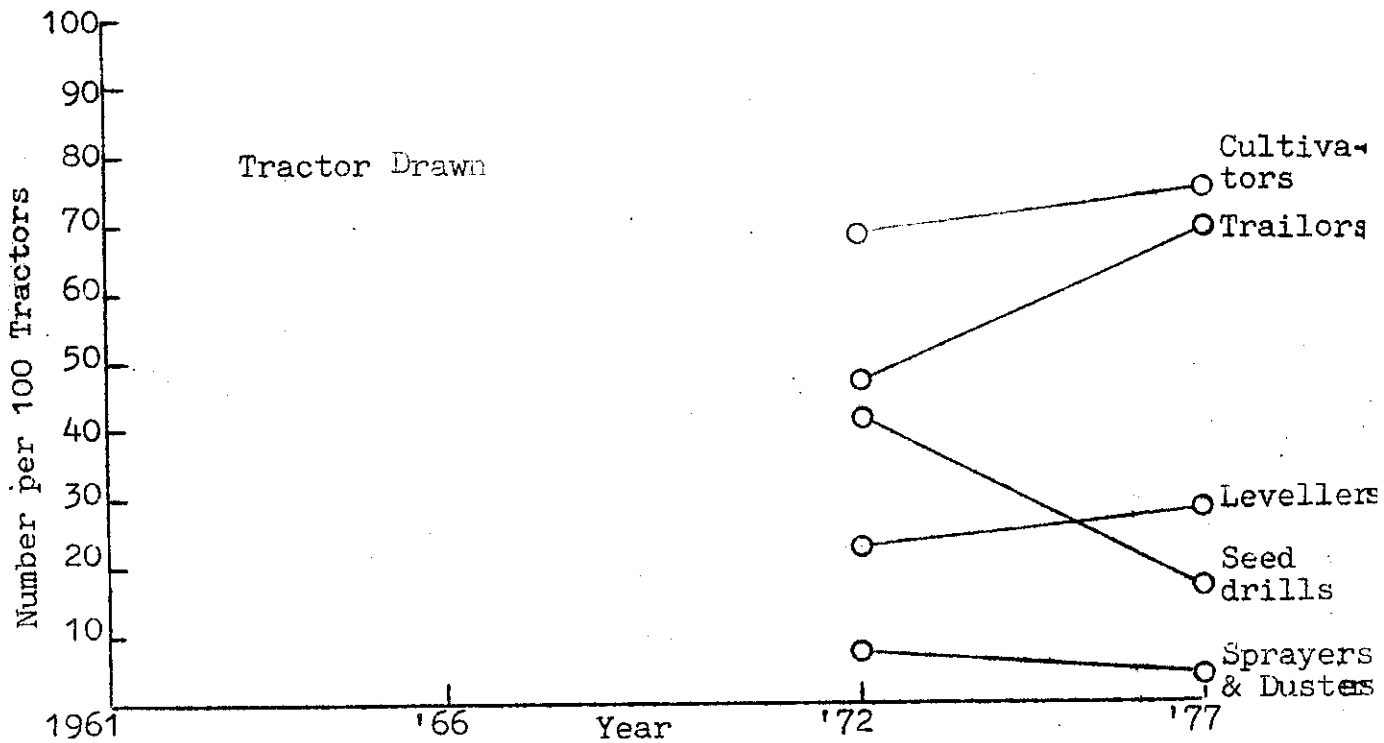
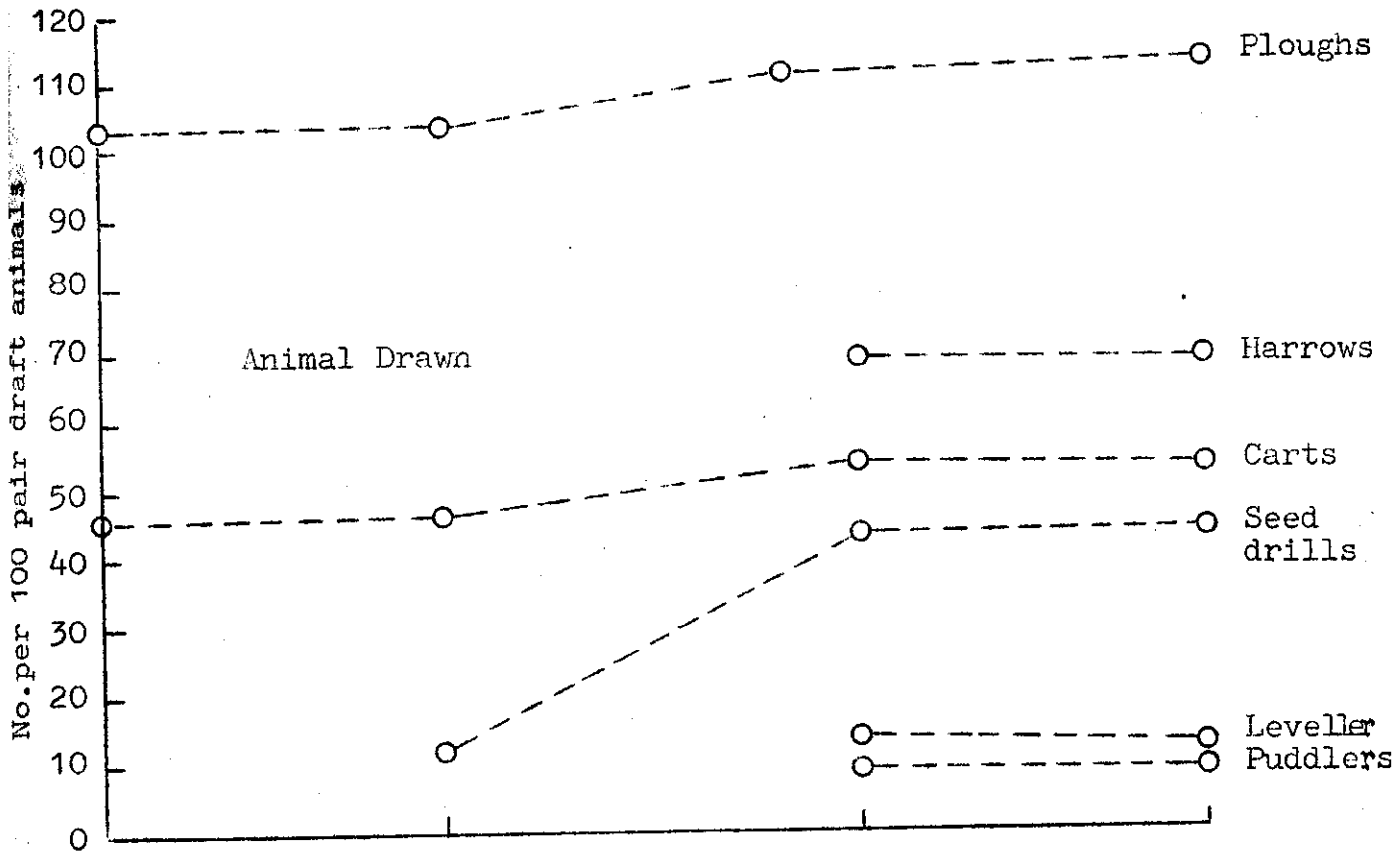


Fig.(3) Some Bullock and Tractor Equipment in Gujarat

second, sowing, planting and transplanting of crops. The third phase, post-sowing, consists of intercultural operations, weeding, cultivations, earthing, irrigation, etc. The fourth phase is of harvesting. The fifth, post-harvest phase, consists of threshing, winnowing, processing storage and transport.

The extent of mechanization will differ from crop to crop. In general, however, the following picture emerges. In the first phase, the dominant position is still held by bullock based equipment. Increasingly, however, tractors are being used, own or on hire, to do the seed bed preparation.

The second phase, sowing and planting, is still dominated by bullock and manually operated equipment.

In the post sowing phase, irrigation has been most decisively taken over by mechanical equipment replacing the bullock operated lifts. Intercultural operations, are still largely done manually or through bullocks. The use of tractor drawn cultivators has, however, been growing. The plant protection operations are also done dominantly by manual equipment. The use of power sprayers on trolley has been growing but not of the tractor run sprayers.

Harvesting of foodgrains and other crops is done manually. Neither bullock nor tractor equipment have gained popularity.

Post harvest phase has been witnessing rapid mechanization next to irrigation and primary tillage. Threshing and transport are being done by tractors and stationary threshers. Processes like oilseed crushing, cane crushing, etc. have been decisively taken over by power equipment from bullocks.

It is difficult to be exact about the extent to which the relative positions of manual, bullock and tractor based operation in Gujarat agriculture today. It appears, however, that the sphere of bullock operations have shrunk more than those of manual operations under the impact of mechanization in general and tractorisation in particular. Still, many critical operations continue to depend on bullocks. The farmers may not dispense with the bullocks until the range tractor equipment increases and their accessibility to these equipment is ensured either through ownership or hiring. The custom hiring has been growing, yet it is neither adequate, nor very reliable (5).

At this stage, some factors need to be mentioned, which may be dampening the process of mechanization in Gujarat and which will need to be taken into account in devising measures to promote mechanization selectively. First, the low level of irrigation and vastness of dryland agriculture will call for special efforts to design equipment suitable for the latter.

The second aspect is the presence of large number of small holdings. Perhaps, this sector will continue to depend for a long time on bullock and manual tools. Thus, vigorous design and development efforts are needed to evolve suitable size of equipment that is less expensive but is efficient.

The third, and perhaps, the most important, is the rising cost of energy and uncertainties in availability of fossil fuels. The strategy for future mechanization will need to be such as to be as conservative as possible energy-wise and dependant more and more on non-conventional sources. Efforts have just been initiated in Gujarat to tap solar and wind energy for agricultural purpose. These efforts will need to be stepped-up.

In relation to mechanization in agriculture in India, it is customary to point to comparatively low farm power availability and advocate increased level of inanimate power. The sharp increase in productivity of agriculture in developed countries of the West is set against the large power input to indicate the gap to be filled in India. It is, I think, worthwhile to point out that the contribution to increase in yields due to mechanization comes through the mechanism of timeliness of completion of operation, precision placement of seeds, fertilizer and water, reduction in losses in harvest, processing, etc. Many a time it is not only mere power but a sophisticated equipment that is crucial. This aspect needs to be kept in mind. More power without matching sophisticated equipment will not result in increased productivity.

Finally, the gap that exists in the knowledge of manual equipment needs to be filled. There is need to conduct surveys aimed at finding out the range and type of manual tools. These tools, apparently are being designed, fabricated and marketed through the artisan based network. There are, ofcourse, some manufacturers of these now, the centres to undertake systematic design improvement are too few in Gujarat.

## 6. Summary

The agro-mechinery situation in Gujarat was surveyed. The amount of farm power available on Gujarat farms was determined. The growth of implements of various types was examined.

The list of implements for which census is conducted, even though expanded over time, is still very limited. The conspicuous aspect is the absence of manually operated tools in the list. It is also necessary to include some specifications in the item of information collected during census.

The amount of farm power available on Gujarat farms in the later part of seventies works out to be 0.59 hp/h. When pumping units are included; excluding these the power reduces to 0.337 hp/hect. This is much below the level - say - in Punjab, and only slightly higher than the national average. In Gujarat, it is the growth of power thru the mechanical pumping unit that has grown the fastest.

The spheres of bullock based farm activities have shrunk to an extent. It is most marked in oilseed crushing and water lifting where it is all but discontinued, having been taken over by power units. Sugarcane crushing too is only minimally done by bullock crushers. Proportion of power crushers has been steadily rising. The use of bullocks in tillage operation seems to have been reduced marginally. The use of bullocks in sowing and transport has increased.

The nature of work that has been mechanized, is mostly such as to reduce the use of bullocks mere than the men. However, it may be some time, before even the reduction in draft animals population is marked. It will depend on emergence of a reliable and wide ranging equipment package and hiring services.

The labour intensive activities in Gujarat agriculture, such as plating and harvesting are yet done mostly manually or through bullock operated tools. Tractor use has expanded mostly in primary, secondary tillages, land shaping operations and to much greater extent in transport of produce. Sowing and plant protection equipment for tractors have not yet gained

acceptance. There are no power harvestors in use.

The review indicates that in coming future, following things will need attention. First the design and development of equipment whose range is very limited both for tractor and bullocks. Such work like groundnut planting harvest and shelling need immediate attention.

Secondly, it will be necessary to develop a strategic plan for mechanization in future. It is not only that more farm power will be needed. More important is the question as to how should it be provided.

Traditional answer - namely more tractors will not be sufficient. The fuel costs are rising, making the minimum size of farm to justify tractor larger. This will make it more difficult than it is already, to reach small holdings by tractors on ownership basis,

It would appear necessary that vigorous efforts be initiated for design and development of fuller range of efficient bullock driven implements. Improvement of manual implements is also warranted.

The development of tractors and related equipment should be continued. This is in view of the fact the existing tractors are under utilized. Part of custom hiring at a wide scale to overcome the size and price constraints of large equipment.

Large part of Gujarat is likely to remain unirrigated. Implements for dry agriculture will need to be given priority. The implementation of dry agriculture will be that it is not so much the time saving feature that needs to be built into equipment design. Rather the working ease and efficiency will need to be emphasized as also low energy consumption.



Table (A-1) Area and Number of Operational Holdings in Gujarat (1971)

Size (hec.)	No. of Holdings	Area (hec.)
1. Less than 0.5	283,957	79,403
2. 0.5 - 1.0	294,577	220,502
3. 1.0 - 2.0	464,202	681,094
4. 2.0 - 3.0	325,367	802,487
5. 3.0 - 4.0	229,312	794,328
6. 4.0 - 5.0	176,469	789,651
7. 5.0 -10.0	424,439	2,957,293
8. 10.0 -20.0	201,201	2,707,609
9. 20.0 -30.0	26,525	620,918
10. 30.0 -40.0	4,496	150,712
11. 40.0 -50.0	986	43,713
12. Bigger than 50	1,036	121,923
<b>Total</b>	<b>2,432,567</b>	<b>9,999,633</b>

Source: Handbook of Basic Statistics Gujarat State 1976. Bureau of Economics and Statistics, Government of Gujarat, Ahmedabad.

Table (A-2) Agricultural Implements in Gujarat - Per live  
Stock Census:

Item	1951	1956	1961
1. Ploughs: a) Wooden	-	1,265,829	1,459,113
b) Iron	-	57,315	105,834
c) Total	1,232,700	1,323,144	1,564,947
2. Carts	516,100	631,700	708,296
3. Sugarcane Crushers:			
a) Power driven	-	1,314	2,008
b) Bullock driven	-	2,598	4,299
c) Total	2,600	3,912	6,307
4. Pumps:			
a) With oil engines	12,100	19,087	44,982
b) Electric motor	800	1,111	6,225
5. Tractors	400	319	1,999
6. Oil crushers	-	5,688	4,097
7. Persian Wheels	-	-	20,804

Source: 1) Quarterly Bulletin of Economics  
and Statistics, Gujarat. Vol.2(1) 1962,

2) Handbook of Basic Statistics, Gujarat  
1960. Bureau of Economics and Statistics  
Government of Bombay, 1960.

Table (A-3) Agricultural Implements in Gujarat -  
Per Livestock Census

Item	1966
1. Ploughs (a) wooden	1,440,965
(b) iron	144,543
(c) Total	1,585,408
2. Improved Harrows, Cultivators	207,816
3. Improved Seed drills	189,019
4. Carts (a) Pneumatic	98,264
(b) Others	634,718
(c) Total	732,982
5. Sugarcane Crushers	
(a) Power	2,100
(b) Bullock	2,677
6. Pumps (a) Oil engine	112,428
(b) Electric motor	14,729
7. Persian Wheels	13,236
8. Tractors	3,189
9. Oil crusher	3,199

Source: Quarterly Bulletin of Economics and Statistics  
 Vol.14(4), 1975, Ahmedabad.

Table (A-4) Agricultural Implements - Per Livestock  
Census, Gujarat

Item	1972	1977
1. Ploughs (a) Wooden	1,488,842	1,375,418
(b) Iron	214,953	240,144
(c) Total	1,703,795	1,615,562
2. Blade harrows	1,051,478	994,194
3. Wet, land Puddlers	144,980	130,195
4. Earth Levellers, scrappers	216,382	168,950
5. Seed drills	661,488	619,422
6. Carts (a) Pneumatic	204,037	247,375
(c) Other	613,602	510,945
(d) Total	817,639	758,320
7. Sugarcane Crushers		
(a) Power	2,529	2,397
(b) Bullock	4,297	2,441
8. Pumps (a) Oil Engines	371,114	422,050
(b) Electric motor	48,377	79,414
9. Persian Wheels	5,891	2,659
10. Crawler Tractors	1,673	3,234
11. Power Tillers	1,122	438
12. 4 Wheel tractors	7,858	11,283
13. Tractor Implements		
(a) Cultivators	6,501	10,748
(b) Levellers	2,220	4,068
(c) Seed drills	3,959	2,408
(d) Trailers	4,459	10,055
(e) Others	-	7,042

--contnd.

(Continuation of Table (A-4))

Item	1972	1977
14. Power Driven machines		
a) Wheat Threshers	5,831	15,192
b) Threshers for other crops	1,451	3,878
c) Other machines	-	2,282
15. Oil Crushers	1,486	898
16. Sprayers and Dusters		
a) Manual	35,932	84,549
b) Power	4,430	15,921
c) Tractors	700	533
d) Total	41,121	101,003
17. Maize shallers	-	8,066

Source: Quarterly Bulletin of Economics and  
 Statistics, Vol.14(4) 1975  
 Vol.20(Special number), 1980  
 Ahmedabad.

Table (A-5) Estimated Number of Agricultural Implement  
Owned Individually per 100 households of  
Cultivators in Gujarat (1977)

Items	Holding Size (Hect.)					All sizes
	<1.0	1-1.9	2-3.9	4-9.9	>10.0	
a) Ploughs						
1) Wooden	38	52	72	83	94	28
2) Iron	3	13	16	23	26	15
3) Total	41	65	88	106	120	43
b) Levellers, Scrappers	3	8	9	14	13	9
c) Harrows, hoes	43	65	97	126	149	17
d) Power Tillers	0	1	2	1	0	1
e) Seed drills	13	19	33	45	64	30
f) Maize shellers	0	0	1	1	1	1
g) Sprayers, dusters	2	3	7	13	19	7
h) Chaff Cutters	0	0	0	1	2	0
i) Threshers	0	0	1	1	1	1
j) Pumps	3	7	21	37	52	20
k) Bullock carts	14	16	35	57	84	34
l) Cane Crushers	0	0	1	1	1	0
m) Oil Crushers	0	0	0	0	0	0
n) Persian wheels	0	0	0	0	0	0
o) Tractors	1	0	0	1	2	1

Source: Gujarat Agricultural Census, Gujarat State,  
 Directorate of Agriculture, Ahmedabad (in press).

Table (A-6) Estimated number of Agricultural Implements  
Owned Jointly per 100 households of Cultiva-  
tors in Gujarat (1977)

Item	Holdings Size (Hect.)					All sizes
	<1.0	1-1.9	2-3.9	4-9.9	>10.0	
1. Ploughs						
a) Wooden	3	4	4	6	6	4
b) Iron	0	0	1	1	2	1
c) Total	3	4	5	7	8	5
2. Levellers, Scrappers	1	1	1	1	1	1
3. Harrows, hoes	3	3	5	10	7	5
4. Power tillers	2	1	2	1	0	1
5. Seed drills	1	1	2	4	5	2
6. Maize shel- lers	0	0	0	0	0	0
7. Sprayers, dusters	1	0	2	3	1	1
8. Chaff-Cutters	0	0	0	0	0	0
9. Threshers	0	0	0	1	1	0
10. Pumps	5	5	5	7	4	4
11. Bullock carts	1	4	4	6	4	4
12. Cane Crushers	1	0	0	0	0	0
13. Oil Crushers	0	0	0	0	0	0
14. Persian Wheel	0	0	0	0	0	0
15. Tractors	0	0	0	0	0	0

Source: Agricultural Census in Gujarat, 1977.  
 Directorate of Agriculture, Ahmedabad  
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