CHAPTER VI

COST OF IRRIGATION BY BULLOCK OPERATED LIFT

In this chapter, the costs of irrigation by bullock operated lift - the traditional mode of lift - are analysed. By its very nature this mode of lift is improvised one, as against the former mechanised ones. Consequently, in respect of this mode, quite a few assumptions had to be made to compute the costs of irrigation, which, in turn, constrained the level of analysis of costs.

Nature of Costs Data

In the following, the nature of data regarding costs of irrigation by this mode has been described to bring out its limitations. Also, some of the assumptions made in respect of computation of costs of irrigation by this mode have been listed out.

In respect of mechanised modes of lift like electric motor and oil engine, the main unit along with other accessories were factory products. Hence, money-costs of investment were available for these modes of lift, since they were transacted in the monetised sector of the economy. However, in case of bullock-operated lift, the main source of motive power, i.e., a pair of bullock, was mostly home-bred.[1] Further, the accessories of the bullock operated lift (such as leather bag, main-string, subsidiary strings) were supplied to the cultivators by the village artisans. These artisans were paid annually in kind for host of services rendered by them, among which the supply of above-mentioned articles was only one. Thus, it can be seen that money-costs of investment on different items of bullock-operated lift could not be had. Under these circumstances, the cultivators using this mode of lift were asked to state the individual prices of these items of investment if they were to purchase them in the market. As such, these imputed values are considered for the computation of cost. However, it must be observed that these values as reported by cultivators operating bullock-lift are only approximate estimates of the costs of different items in contrast to actual money costs expended by the cultivators operating electric motors and oil engines.

Cost of Bullock Labour

Similar problems were encountered in estimation of cost

1 Out of 59 bullock-operated lifts, in respect of 54 lifts, the cultivators reported the pair of bullock being home-bred.

of bullock labour for its use for irrigation purposes. The problem had two dimensions as discussed below :

The first dimension of the problem pertained to the estimation of cost of bullock feeds, which, in most cases, were the by-products of the foodcrops (like Jowar-straw, Bajra-straw, Paddy-straw, Maize, Lucerne-grass and their husks etc.) grown on cultivator's own farm.

This problem was solved in the similar fashion as that of estimating investment cost of different items, viz., the cultivator being asked to state the value of the feed-stock actually given to bullocks if he were to buy the same from the market.

The second dimension of the problem was of more intricate nature. The bullock-power, as is commonly known, is utilized for many of the farming operations such as ploughing, harrowing, ridging, sowing, puddling and threshing apart from irrigation. Besides, it is also utilized for non-farming operations like carting, crushing of sugarcane and oil-seeds, etc. The same pair of bullocks is utilised for all these operations along with its use for irrigation purposes and also it may be noted that the bullock-pair is not necessarily kept engaged for all the days in a year.

Since the feed-cost of bullock-holding of a cultivator was available for the year as a whole, the problem boiled down to apportionment of feed cost for idle days of bullock-pair between its employment for irrigation purposes and its employment for all other purposes inclusive of farming and non-farming operations. The problem could be tackled if the estimates of employment of bullock-pair were to be available separately for different farming and non-farming activities for the reference period. However, the data was collected only on employment of bullock power for irrigation purposes during the reference period and no information on the details of employment of bullock-labour on other farm and non-farm activities was sought. Irrigation being a major farm activity, and the number of days of irrigation and timings being, more or less, given according to the nature of the crop, it was thought that farmer's memory would be more reliable in the matter of number of days of use of bullock power for irrigation, and hence, taxing the farmer's memory for other details of uses was avoided. Further it was thought that if data on number of days of use of bullocks for irrigation was available, and also one had a fair idea of the normal number of working days of a bullock in a year, it would suffice the purpose in hand, i.e., that of apportioning the cost of bullock maintenance for irrigation purposes. Estimates of normal number of working days of a bullock in a year were generally available from Farm Management Reports.

In the year 1967-68, Gokhale Institute of Politics and Economics, Poona, conducted a farm management survey in Ahmednagar District under the auspices of Ministry of Food and Agriculture.[1] Some of the results of this farm management study, particularly pertaining to number of days of employment of bullock-pair in a year were available and hence, it was decided to use these for the allocation of annual cost of maintenance of bullock pair between its employment for irrigation and non-irrigation purposes.

It might be mentioned here that average number of working days of a pair of bullocks for all size-groups of cultivated holding as brought out by this report is considered for working out cost per working day. It is relevant to note that the aforesaid farm management report observed that there was little variation in the normal working days of bullocks in a year over different sizes of cultivated holdings. On the basis of this estimate of normal working days in a year, the cost of bullock-pair apportionable to its irrigational use was arrived at. Details of employment of bullocks for irrigation purposes in respect of each of bullock-lifts in the sample were, of course, collected, gathering information on number of hours of operation of lift for watering different crops during the reference period.

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1 Gokhale Institute of Politics & Economics, Farm Management Survey in Ahmednagar District, Poona, 1970 (Mimeographed)

Components of Costs

In the following, items falling under different components of costs are described.

Fixed costs : Fixed costs consist of two items, viz., (a) wooden superstructure constituting wooden pillars (ziga)[1] on two sides with one wooden log (Vadav) resting on top of them,[2] and (b) Leather bag (mhot) which brings water from the well.

Variable costs : These costs consisted of annual costs on three categories of items mentioned below :

(a) Consumables during the year such as accessories attached to mhot, i.e., main string (Nada) and subsidiary strings (saundar), wooden accessories attached to superstructure, i.e., wheel (Chak) on which the main string rolls, wooden plank (Kana) which keeps the strings away from inner wall of the well so as to keep clear the mhot off it, and small wooden pieces (Butlya) by the help of which mhot, when it comes up, is overturned to channelise the water inside it to the crops in the field.

(b) Cost of maintenance of bullock power apportionable

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1 Local names of items are given in bracket against the description of the item.

2 The wooden structure is an edifice on which the entire operation of lifting water is carried out. It consists of 5 branches of tree in all, of which 4 are erected on the ground in the following fashion.

At a distance of 10-15 feet, 2 stems are erected on each side in a slanting manner so as to form a triangle with the ground as base. Thus two separate triangles are formed at a distance of 10-15 feet between them. On the vertices of these triangles stem is put parallel to the ground.

to its use for irrigation purposes during the year, and

(c) cost of human-labour required to operate the mhot during the year under reference. In respect of electric motor or oil engine, no person was specially required to supervise its working once it was started, since supervision was occasionally needed, if at all. This was not the case with bullock lift where continuous supervision of a person was required for the operation of mhot. The pair of bullocks had to be hackled towards and away from the well on a strip of land to draw water from it with the help of mhot. Further, the pair moved in backward direction (tail facing the well) when it walked towards the well, thus calling for supervision and lastly, the mhot had to be emptied mannually when it came up. To perform these operations, a person was exclusively required to supervise them.

Apart from the above, annual maintenance cost of mhot (which lasted for more than 1 year) such as costs incurred on tailoring of mhot, soldering of side rings and its oiling has been included under the variable costs.

It may be noted that the mhots which were reported to have lasted for only one year have been considered under variable cost and not fixed cost, and hence, in their respect no depreciation charge and interest costs have been computed. Out of 78 Mhots covered by sample lifts, as many as 35 lasted for one year and 43 lasted for more than one year.

Computation of Fixed Costs

Fixed costs consisted of (a) depreciation charges, and (b) interest costs. Depreciation charges are the costs of using the equipment during the year under reference and as such are based on initial cost of equipment and the life of equipment. In respect of wooden structure and mhot, these costs are considered on the basis of initial costs and the life of these items reported by the cultivators.

Interest costs in respect of mhot are computed on depreciated value of the mhot at the beginning of 1965-66, since the year of purchase of mhot and its life could be precisely stated by the cultivators. However, in respect of wooden structure, interest costs are computed on per annum cost of investment and not on depreciated value of equipment for the following reasons :

(a) In respect of sample bullock-lift being operated on more than one well, the respondent did not have the information regarding the year of erection of wooden structure due to the fact that on jointly-owned wells, the structure was erected by the partners in rotation.[1]

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1 In respect of mechanised modes, the initial investment cost was actually shared. Since the cost of wooden structure was nominal and wood being available in plenty, its cost was not shared but was erected in turn.

(b) In respect of wells where ownership rights were divided, the respondents turn to erect the structure came once in 25 to 30 years since the average span of life of the structure was 5 to 10 years and average number of partners in such wells being 4 to 5. It was, therefore, thought that per annum cost of investment was more relevant for a cultivator than the depreciated value of equipment.

Since these items were financed out of owned sources, the rate of interest considered for computing interest costs was 3.5 per cent per annum, as stated in earlier chapters.

Computation of Variable Costs

Apart from costs incurred on consumables during the year under reference, the major part of variable costs consisted of estimates of annual maintenance charges of bullocks utilised for irrigation purposes and costs of human labour utilised for operation of lift.

Maintenance Cost of Bullocks : For computation of total maintenance cost of owned bullocks during the year, the following components of costs are considered :

(1) Depreciation on value of bullocks;

(2) Interest rate charges on value of bullocks[1];

1 Conceptually, depreciation and interests are in the nature of fixed costs. However, in the present context, since bullocks are not used exclusively for irrigation purposes, and since appropriation of these costs towards irrigation is in proportion to the irrigation-days performed, they become variable costs, i.e., varying in proportion to the work performed.

(3) Value of fodder and concentrates given to bullocks;

(4) Upkeep value;

(5) Other expenditure; and

(6) Value of farm-yard manure extracted.

While the costs of items 1 to 5 have been added up, the value of item No.6 has been deducted from the sum of items 1 to 5 to arrive at total maintenance cost of bullocks.

It may also be noted here that the costs/values of items 1 to 3 and 6 have been directly estimated from sample data, while the costs incurred on items 4 and 5 have been estimated on the basis of the earlier-stated Farm Management Report prepared by Gokhale Institute of Politics and Economics for Ahmednagar District in the year 1966-67.

The Item No.4, i.e, upkeep value, represents the cost of family/hired labour employed for maintenance of bullocks. Thus speaking, the up-keep value includes the labour cost employed exclusively for washing the bullocks, cutting the fodder, taking the bullocks out to green pastures, etc. It may be observed that it was not possible to estimate these costs directly, hence the cost incurred on this item is estimated as described below.

In the above mentioned Farm Management Study, this cost (upkeep value) is worked out to be 17.6 per cent of the cost incurred on fodder and other bullock feed. It may be pointed out that most of the cost of human labour incurred on upkeep of bullocks relates ultimately to the labour involved in feeding the bullocks such as cutting the fodder, arranging it, feeding it daily at some fixed rate (say, two straw bundles), and taking them for feeding fresh grass to green pastures of the village. No doubt, some of the labour cost involved relates to cleaning the cow-shed, washing the bullock, etc., but it is assumed that the major contribution of labour cost in upkeep value would be of the labour involved for feeding the bullocks and hence we have related it to 'feed cost' and taken as 17.6 per cent of cost incurred on bullock-feed.

Similarly, the expenditure on item No.5, namely, the other expenditure, consisting of expenses incurred on medicines, ointments, etc., for bullocks is related to cost of fodder and concentrates given to bullocks. As per the finding of above-cited Farm Management Study, the expenditure on this item constituted 1.06 per cent of the cost of fodder and concentrates given to bullocks. The same proportion of cost of fodder and concentrates is assumed for computing the cost under this head.

<u>Apportionment of Costs</u> : As in the case of electric motor and

oil engine, here also, the respondents were asked to state the number of crops irrigated by this device, the number of irrigations given to each crop and the duration of each irrigation. Based on these data, extent of use of bullock labour for irrigation purposes during the year 1965-66 is estimated. It may be observed here that bullock-operated lift is also a mobile unit like oil engine and, therefore, in the estimation of the use of bullock labour for irrigation purposes, the deployment of bullock-pair/pairs at all the irrigation wells of the respondent is taken into account.

At the rate of 8 hours of working per day, the number of working days of bullock-pair for irrigation purpose is arrived at from total hours of irrigation of all the crops during the year by this device. The total maintenance cost of bullocks during the year is apportioned for use of bullocks for irrigation purposes in the same proportion in which total days of their utilisation for irrigation purposes were in the normal working days in a year. Based on the findings of above mentioned Farm Management study, normal working days of a pair of bullocks are assumed as 172.72 days in a year.

Cost of Human Labour : Total hours of human labour gone into operation of mhot (based on hours of irrigation to different crops during 1965-66) are converted into man-days at the rate of 8hours of working per day.

The cost of total man days required for operation of mhot are converted into value terms on the basis of prevailing wage rate of casual agricultural labour in the village in which it was being operated. It may be mentioned here that out of 59 cultivators operating sample modes of traditional (bullock operated) lift, as many as 52 operated the lift themselves or got it operated by their family members, while only 7 had employed farm servant for its operation.

Although both the estimates of bullock pair hours and man hours gone into operation of lift are based on the total number of hours for which the mhot was operated during the year for irrigating the crops, these two estimates for the same respondent differ widely in actual computation because of the peculiar combination of bullock pair hour and man hour in the operation of mhot, as discussed below.

Just as electric motors and oil engines were of different sizes (in terms of Horse Power), so were the bullock operated lifts. In the sample, 4 different sizes of bullock operated lifts were found, classified in terms of number of bullocks operating (pulling) the number of mhots.

Corresponding to the four sizes of bullock-operated lifts, the requirement of persons to drive the bullocks also differed, as shown below :

	Size of the lift	No.of persons driving the bullocks
1.	A pair of bullocks pulling one mhot.	One
2.	Two pairs of bullocks pulling two mhots.	One
3.	Two pairs of bullocks pulling one mhot.	One
4.	Three pairs of bullock pulling three mhots.	Two

Due to the above stated combinations of bullocks pair/ pairs and human labour employed in the operation of different sizes of lift, the estimates of pair hours and man hours utilised for the operation of lift differed according to the sizes of the lift.

Level of Operation of Bullock-Lift

Costs of irrigation of electric motors and oil engines have been analysed with respect to their hours of operation during the year. In respect of bullock-lift, the costs of irrigation have been analysed with respect to bullock-pair-hours of operation during the year 1965-66. In this context, it may be noted that for analysis and computation of irrigation costs at different levels of operation, we have not treated each size of lift (as mentioned above) separately. Instead, we have considered all sizes of lifts together for the analysis of costs of irrigation at different levels of operation. In other words, we have assumed that efficiency of each size of lift is directly proportional to number of bullock pairs deployed in the operation and computed costs for different levels of operation in terms of pair hours.

We have adopted the above stated method for computation and analysis of irrigation costs for the following reasons :

(a) The motors and engines being few in number in the villages and their rated capacities being well defined and, therefore, widely known, the details of each motor and engine could be had apriori from Gramsevak or village Patwari for their stratification and systematic selection. Such was not the case with bullock-operated lifts. The bullock operated lifts, being operated on all the remaining wells, were, therefore, in large number; (b) since the rated capacity of any bullock operated lift is not precisely defined as in the case of motor or engine in terms of H.P., all that the Gramsevak or any other man in the village could tell was that on a particular well a bullock operated lift was operated without being able to furnish any further details about the size of the lift. Hence it was not possible to select systematically the bullock-operated lifts of different sizes, (c) it was thought that to a certain extent it could be assumed that the rated capacity of the bullock operated lift could be related to number of bullocks operating the lift, and (d) number of each size of lift classified on the basis of number of bullock pairs and mhotes has turned out to be quite small in the sample for any generalisation and, therefore, for the purpose of analysis of costs, we have pooled them together.

Sample of bullock-operated lifts

In Table 6.1, the description of sample of bullock-operated lift is provided, giving distribution of lifts village-wise and size-wise. The classification of lifts into different sizes is based on number of bullocks pulling number of mhots. Further, the table also presents data on average size of ownership of bullocks for cultivators operating the lift of different sizes. This is to see the extent of correspondence between the number of bullocks employed for operating the lift by cultivators and the number of bullocks owned by them.

It may be observed from Table 6.1 that, by and large, the sample cultivators have individually employed such number of bullocks for lift purposes which was within the size of their bullock-holding. In other words, the extent of borrowing of bullocks for irrigation purposes was small in the sample.

In fact, only 6 cultivators using these lifts had owned less number of bullocks than deployed for irrigation purposes. Thus, almost 90 per cent of cultivators owning sample lifts had owned equal or more number of bullocks than employed for irrigation purposes. Perhaps, the cultivators did not wish to depend on others for such vital an operation as irrigation

Table 6.1 : Distribution of sample of bullock-operated lifts.

Name of the village	Total no.of bullock operated lifts selected	Distribution of sample lifts by no. of mhots and no. of bullock-pairs operating the lift							
		A mhot operated by pair of bullocks		A mhot operated by two pairs of bullocks		Two mhots operated by two pairs of bullocks		Three mhots operated by three pairs of bullocks	
		No.of cases selected	Av.size of bullock holding	No.of cases selected	Av.size of bullock holding	No.of cases selected	Av.Size of bullock holding	No.of cases selected	Av. size of bullock holding
1	2	3	4	5	6	7	8	9	10
1. Phursungi	4	-	-	4	4.00	-	-	-	-
2. Narayangaon	5	3	2.00	-	-	2	3.00	-	-
3. Chikhali	5	1	2.00	4	4.50	-	-	-	-
4. Retawadi	5	1	2.00	-	-	3	3.67	1	6.00
5. Dawadi	5	4	2.00	-	-	1	4.00	-	-
6. Narodi	4	-	-	-	-	3	4.00	1	6.00
7. Walunj	3	-	-	3	3.33	-	-	-	-
8. Shivari	4	-	-	4	5.25	-	-	-	-
9. Mahalunge	5	4	3.00	-	-	1	4.00	-	-
10. Shinoli	5	4	2.00	-	-	1	2.00	-	-
11. Vadgaon	5	5	5.20	-	-	-	-	-	-
12. Parunde	5	2	1.50	-	-	3	3.33	-	-
13. Ranjangaon	4	3	2.00	-	-	1	4.00	-	-
Total	59	27	2.70	15	4.33	15	3.47	2	6.00

of crops. Two points may be noted here regarding those cultivators whose own bullock holding was smaller than the one employed by them for irrigation purposes.

Of the 6 cultivators who had engaged hired bullocks for irrigation purposes, the irrigational requirement of 3 cultivators, individually, was very small. Their individual requirements of bullock-pair days for irrigation purposes as reflected by the actual total number of hours of irrigation during the year were 2.75 pair days, 11.56 pair days and 13.50 pair days. Corresponding to their total requirements as stated above, they had hired respectively, 1, 2 and 2 bullocks for irrigation purposes, while they owned 1, 2 and 2 bullocks, respectively.

Of the remaining three, whose total requirements were large, individually, being 47 pair-days, 42.5 pairdays, and 28.81 pair days, the first two in the above order had depended on their nearest kith and kins for hiring bullocks for irrigation purposes. These two owned a pair of bullocks each while they hired two bullocks each. Both stated that they could fully depend upon their relatives for these bullocks. The remaining one owned 3 bullocks and hired one for operating the lift consisting of 4 bullocks.

Thus in majority of cases of cultivators who depended on outside bullocks for operation of bullock lift, either the total requirement of irrigation in terms of pair-days had been low or in such cases where the requirements were high, the outside agency for the supply of bullocks could be relied upon by the cultivators.

It may be noted that those cultivators who employed outside bullocks for operating the lift did not actually hire them by paying certain amount as rent. The practice of mutual exchange of bullocks (locally known as 'Varangula') was prevalent in the district. However, under the practice when a particular cultivator brought the outside bullocks for any work, the entire cost of feeding would be borne by that cultivator during the period of hiring. Thus, this practice justified the above-stated method of apportionment of cost (based on number of pair days utilised for irrigation out of total normal working days in a year) even in such cases where the cultivator did not possess enough number of bullocks for irrigating the crops.

The above table would create an impression that there was a relationship between the requirement of bullocks for irrigation purposes and the size of bullock-holding of the cultivator. However, no firm relationship is observed in sample data between size of bullock holding and the irrigational requirement of the cultivator as can be seen from table 6.2.

In table 6.2 we have classified the cultivators operating sample lifts by total pair hours of irrigation and the pair of bullocks owned by them.

Table 6.2 : Distribution of cultivators by ownership of bullocks and the bullock-pair hours operated for irrigation purposes.

Pair hours operated for irrigation \ Pair of bullocks owned	Number of cultivators								Total No.of cultivators
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	
0-400	1	16	-	2	-	4	-	-	23
400-800	-	7	1	5	-	1	-	-	14
800-1200	-	2	-	7	-	-	-	-	9
1200-1600	-	-	-	3	1	1	-	-	5
1600-2000	-	-	-	2	-	1	-	1	4
2000-2400	-	-	-	3	-	1	-	-	4
Total No.of cultivators	1	25	1	22	1	8	-	1	59

It can be observed from table 6.2 that though at the higher level of requirement of bullocks (in terms of pair-hours) for irrigation purposes, the cultivators had maintained greater number of bullocks, i.e., 2 pairs and above, at lower level of requirement of bullocks for irrigation purposes, some of the cultivators had still maintained a larger number of bullocks, i.e., 2 pairs and above. For example, it can be observed that 12 cultivators having 800 pair hours of irrigation or less had still maintained more than two pairs, and in some cases (5 cultivators), even three pairs of bullocks.

This is a pointer to the fact that bullocks being useful in many ways to the cultivator, both for farm and non-farm activities, its holding cannot be related to its one use. Similarly, from table 6.3, it may be observed that no relationship was seen between the size of cultivated holding and the size of bullock-holding in respect of cultivators owning sample lifts. It may be mentioned here that even the Farm Management Report cited above did not observe any relationship between the cultivated holding and bullock-holding. In the absence of any relationship between cultivated holding and bullock-holding of the cultivators, we have assumed that irrespective of size of holding, a pair of bullock is employed for certain number of days (normal working days) in a year.

In the following sections, computational results of different components of costs of irrigation are presented. The focal point in the analysis of costs has been to find out whether the reported costs are consistent with the general notions, since most of these costs were imputed rather than directly expended by the respondents.

Wooden structure : Each respondent was asked to state the cost of wooden structure where he was found operating the lift. Similarly, his estimate of the life of the structure was also asked so as to arrive at its per annum cost. In table 6.4, the costs of wooden structure and its expected life as reported by the cultivator, are presented. It may be noted that where the cultivator had more than one well on which bullock lift was

Table 6.3 : Distribution of cultivators by bullock-holding and cultivated holding

Size of bullock holding \ Size of cultivated holding (In Acres)	Number of cultivators									
	0-4	4-8	8-12	12-16	16-20	20-24	24-28	28-32	32-36	36-40	Total no.of cultivators
1	-	-	-	1	-	-	-	-	-	-	1
2	2	6	8	5	1	2	1	-	-	-	25
3	-	-	1	-	-	-	-	-	-	-	1
4	1	5	4	3	2	4	2	-	-	1	22
5	-	-	-	-	1	-	-	-	-	-	1
6	-	-	2	2	3	-	-	-	1	-	8
7	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	1	-	-	-	1
Total no.of cultivators	3	11	15	11	7	6	4	-	1	1	59

Table 6.4 : Distribution of cultivators by the reported costs and life of wooden structure.

Cost of wooden structure (Rs.) \ Life of wooden structure (In Yr.)	Number of cultivators 0-3	4-6	7-9	10 & above	Total No.of cultivators	Average life (In year)
0-40	17	9	4	3	33	4.18
41-80	1	7	4	11	23	7.56
81-120	-	-	-	3	3	10.00
Total No. of cultivators	18	16	8	17	59	

operated, it is assumed that per annum cost of wooden structure is the same at all such wells. Hence, in table 6.4, we have tabulated above-mentioned data for 59 wooden structures corresponding to 59 cultivators operating sample lifts, although, the number of wells where they operated the bullock-drawn lift were more than 59.

It can be observed from Table 6.4 that, as normally expected, there is a positive relationship between the two estimates of the respondent regarding the cost of the wooden structure and its life.

However, it may be observed that for the same investment cost group, large variations are observed in the estimates of life reported by the respondents. This is due to some element of arbitrariness gone into the estimates of cost and life of the structure, particularly when the structure was not erected by the respondent but by his partner.

It is to be noted that we have not attempted to define the economic life of the wooden structure and link it to its utilisation. This is for the following reasons. Where the wooden structure was commonly owned it was difficult to estimate the total hours of mhot operation of all the partners withstood by the structure during its life. In respect of engines and motors, where the investment-cost is considerable, it could be assumed that the partners owning the engine/motor would use it in proportion to their ownership rights. Hence knowledge of the pattern of utilisation of one partner and his ownership right in the engine/motor was sufficient to estimate the total hours of utilisation of the unit by all the partners in a year. In respect of wooden structure, however, it is to be observed that its mere existence did not ensure its utilisation by all the partners because of the peculiar manner in which its cost was shared. If all the partners individually did not possess bullocks, some of them might not operate the lift, in spite of the structure, since the cost of structure formed a very small portion of total costs of irrigation by this device.[1] In respect of

1 Out of a total of 59 cultivators operating sample lifts, in respect of 32 cultivators, per annum cost of wooden structure worked out to be less than 1 per cent of their total costs of irrigation. In respect of another 17 cultivators, it was between 1 and 2 per cent of the total cost of irrigation. Of the remaining 10 cultivators, only in respect of 6 cultivators, it had exceeded 5 per cent of their total costs of irrigation.

costs of other items such as mhot, accessories attached to mhot and wooden accessories attached to wooden structure, we have attempted to relate the costs to the level of utilization of lift, since these items were individually owned.

Mhot : As stated earlier, the mhot is a device which draws water from the well for irrigation of crops. It was in most cases, made out of leather and had a triangular shape with an opening at the vertex, which, when dipped into the water, filled the mhot. It came up the well in a slanting manner with vertex in skyward direction. The vertex was opened or closed through loosening or tightening of subsidiary strings attached to it. By and large, mhot contained 32 to 36 gallons of water although, the quantum depended upon its size.

Broadly speaking, two types of mhots were found to be in operation in sample villages. They were (a) leather-based, and (b) tin-based. However, mhots made out of tin were found only in two villages, namely Shivari and Walunj, while in rest of the sample villages mhots prepared out of leather were in operation. Out of 78 mhots covered by sample lifts of the cultivators, only 7 mhots (less than 10 per cent) were made out of tin, while remaining 71 were made out of leather.

The sample mhots made out of leather could be further classified on the basis of their sizes. Broadly, two sizes were found to be predominent, one containing 32 to 36 gallons of water and the other containing 48 to 50 gallons. This latter type of leather bag could be compared with tin-mhot which had a capacity of 48 gallons.

It may be noted that these bigger sizes of mhots (containing 48 gallons to 50 gallons of water) were drawn in all cases by 4 bullocks (Two pairs) and smaller size of mhots (containing 32 to 36 gallons of water) were drawn by a pair of bullocks.

As regards the cost of different types of sample mhots, the cost of leather mhot of smaller size ranged between Rs.50 and Rs.80, while the cost of leather mhots of bigger size ranged between Rs.100 and Rs.125. The cost of tin-mhots ranged between Rs.80 and Rs.110. For each size of mhot, the difference in the cost was due to difference in payment in kind (in foodgrains, etc.) to the cobbler rather than difference in the quality of the mhot itself.

The minimum life of leather mhot was observed to be one year. The maximum life appeared to be depending upon its extent of use and its oiling and maintenance. In table 6.5, data on life of mhot and its extent of use by the cultivators in respect of 71 leather mhots are presented.

Table 6.5 reveals inverse relationship between the extent of use of mhot and its life. Out of total number of mhots in

Table 6.5 : Distribution of leather mhots by their economic life and their extent of use.

Hours of use of Mhots. (size-group) \ Life of mhots in years	Number of Mhots			Total no.of mhots
	1	2	3	
0-200	-	12	7	19
201-400	6	10	1	17
401-600	11	4	-	15
601-800	9	2	-	11
801-1000	5	-	-	5
1001-1200	4	-	-	4
Total no.of mhots	35	28	8	71

each size-group of hours of operation, the proportion of mhots lasting for two years and over declines as onemmoves from lower size-group of hours of operation to higher size-groups. No mhot appears to be lasting for 3 years beyond 400 hours of use per annum, and for two years beyond 800 hours of use.

It may also be observed that the cultivators whose mhots lasted for two years and above, had spent comparatively larger amount per annum on oiling and maintenance of their mhots. For instance, in size-group of 201 to 400 hours of operation, the average per annum expenditure incurred on mhots lasting for one year was Rs.3.83 while for mhots lasting for two years and above, the average maintenance and oiling expenses were of the order of Rs.8.14 per annum. Similarly, in the size-group of 401 to 600 hours of operation, average maintenance cost per annum for mhots lasting for one year was Rs.5.10, as against those lasting for two years, Rs.14.38. In the size-group of 601 to 800 hours of operation, per annum cost of maintenance was Rs.5.20 and Rs.20.00 per mhot for mhots lasting for one year and two years, respectively.

Incidentally, one interesting result emerges out of comparison of operational cost of two types of mhots, namely leather and tin mhots. Out of 15 mhots, each drawn by two pairs of bullocks, 8 were leather-mhots, while 7 were tin-mhots. In Table 6.6, we have presented relevant costs of the mhots so as to compare the economics of their operation.

Table 6.6 : Investment and operation cost of mhots of 2 types - leather and tin mhots.

	Leather Mhots	Tin Mhots
Average cost of mhot (Rs.)	105.00	97.86
Average hours of operation (No.)	528.75	620.86
Average life (No.) (In years)	1.75	7.57
Average maintenance cost (Rs.)	16.81	12.71
Per hour cost of accessories attached to mhot (Rs.)	0.19	0.14

Though the number of observation of both the types of mhots are small, it can be observed that data presented in table 6.6 show lower operational cost for tin-mhots vis-a-vis leather mhots. Not only tin-mhots cost less but also their operation & maintenance costs were lower and their longevity higher as compared to leather-mhots. Further, even though tin mhot was heavier in weight, the cost per hour of operation incurred on accessories (main strings + subsidiary strings) was much less as compared to leather-mhots despite higher level of their utilisation.

In spite of economies in cost of operation of tin mhots, these mhots were found only in two sample villages namely, Shivari and Walunj of Purandhar taluka. In other sample villages, we did not come across these types of mhots.[1]

<u>Accessories tied with the leather bag</u> : As stated earlier, these accessories consisted of two types of strings (main and subsidiary) attached on one side to mhot and on the other to the yoke placed on the back of the bullocks. Of 2 types of strings, the main string was thicker in size (its diameter was bigger) than the subsidiary string which was not only thinner

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1 Because we came across this phenomenon (existence of tin-mhot) quite late in the course of survey, we could not ascertain the reasons for its existence in particular villages and absence in others. The existence of these two types of mhots can therefore be compared to existence of two types (brands) of electric motors or oil engines of same capacity (H.P.).

but also due to its direct contact with the earth wore out faster. The proportion in which main string and subsidiary string were utilised in the operation of mhot was 1:2. Hence, where two mhots and three mhots were employed in the lift, larger number of strings of both the types of were required for its operation, and per annum cost on these items went up. Also, where smaller size of lift (consisting of one mhot either drawn by a pair or two pairs) was in operation but was utilised to a greater extent in terms of pair hours, per annum cost on these items had gone up mainly because of fast wearing of subsidiary strings and in very few cases of main strings also.

Thus, we have observed positive relationship between level of operation of lift in terms of pair-hours and per annum cost on these accessories which can be guaged from the Table 6.7.

Table 6.7 shows positive relationship between the level of utilisation of lift (in terms of pair hours) and the cost of accessories tied to leather bag. However, in the last size-group (2000-2400 pair hours) the average cost appears to have come down. This is due to 3 cultivators having employed iron chains as subsidiary strings. As these chains were stronger than the ropes, the cost had come down considerably for these cultivators.

Table 6.7 : Distribution of cultivators according to reported cost of accessories and different levels of utilisation.

Utilization of lift in pair hours (size groups) / Per Annum cost of accessories (In Rs.)	Number of cultivators						Total No.of cultivators	Average cost of accessories
	0-25	25-50	50-75	75-100	100-125	125-150		
0-400	11	11	1	-	-	-	23	26.87
400-800	1	7	3	3	-	-	14	52.82
800-1200	-	1	4	4	-	-	9	68.69
1200-1600	-	-	1	3	1	-	5	85.50
1600-2000	-	-	1	1	2	-	4	97.00
2000-2400	-	1	2	-	-	1	4	86.00
Total no. of cultivators	12	20	12	11	3	1	59	52.98

The distribution of cultivators by costs (in size-group), reported by them of these items also shows relationship between level of utilisation of lift and cost. As can be observed from table 6.7, out of 37 cultivators operating lift for less than 800 pair hours, as many as 34 (i.e., 92%) reported cost on accessories tied to mhot of less than Rs.75. However, in respect of cultivators operating lift beyond 800 pair-hours, the proportion of cultivators reporting cost of less than Rs.75 declines to 45 per cent.

Wooden Accessories : As stated earlier, these accessories consisted of a wheel (chak), a wooden plank (kana), and small wooden pieces (Butlya).

In Table 6.8, we have presented the cost on these three items as reported by the cultivators. Further, as the cost could be related to the levels of utilisation we have presented cost against its level of utilisation.

Average cost of these wooden accessories has turned out to be meagre, i.e., Rs.4.60. However, cost incurred on accessories seems to be rising for higher level of utilisation in terms of pair hours. This rising trend of cost at higher level of utilisation is normally expected. The number of "chak", "kana" and "butlya" employed for operation of mhot varies directly with the number of mhots employed. For example, while for a pair of

Table 6.8 : Distribution of cultivators according to cost of wooden accessories and levels of utilisation of lift.

Pair hours of utilisation (in size-group) \ Cost of wooden accessories (In Rs.)	Number of cultivators						Total No.of cultivators	Average cost
	0-3	3-6	6-9	9-12	12-15	15-18		
0-400	12	11	-	-	-	-	23	2.91
400-800	2	10	1	1	-	-	14	4.92
800-1200	1	6	1	1	-	-	9	5.16
1200-1600	-	3	1	-	-	1	5	7.05
1600-2000	1	1	1	1	-	-	4	5.83
2000-2400	-	1	2	1	-	-	4	7.61
Total no.of cultivators	16	32	6	4	-	1	59	4.60

bullock drawing one mhot only, one "chak" and one "kana" and four "butlyas" are required, in respect of two pairs drawing two mhots, exactly double the quantity of each of the items is required. Under the circumstances, where the utilisation of lift is higher in terms of pair hours because the bigger size of lift was employed, higher per annum cost was expected. However, higher cost at lower level of utilisation arose, in certain cases, because of breakage of items or its loss due to negligence.

<u>Bullock Labour</u> : In the first place, we have computed the cost of maintenance of owned bullocks for the year and then apportioned it for irrigation purposes in ratio of number of bullock days utilised for irrigation purposes to total number of working days of bullocks in a year.

Further, as discussed earlier, we have considered the following 6 components of cost in determining the total cost of maintenance of bullock in a year. They are : (i) depreciation on value of bullock, (ii) interest rate charges, (iii) cost of feed and concentrates, (iv) upkeep value, (v) other expenditure, and (vi) value of farm yard manure.

It may be noted that expenses incurred on items (iv) and (v) have been determined on pro rata basis as certain percentage of cost of feed and concentrates.

Farm yard manure : As regards farm yard manure, which is not an item of cost from the cultivator's view point but an item of income, and therefore deductable from gross maintenance cost of bullock, the respondents were asked to state the total quantum of farm yard manure from owned bullocks during the year and its value. The quantities were stated in terms of cart-load of farm yard manure.

According to Farm Management Report prepared by Gokhale Institute, the estimate of farm yard manure per animal (Bullock) is 6 to 10 cartloads per annum with one cart-load equal to 8 maunds, and with daily output per animal being 0.134 maunds.

Surprisingly, our sample estimate, as reported by cultivators of average number of cart-loads of farm yard manure per animal per annum is close to the above stated estimate being 6.16 cartloads, although we had not gone into details of measuring daily output, etc. However, the estimate of cart-loads per animal per annum varied from cultivator to cultivator and ranged between 4 cartloads and 10 cartloads.

There was, however, an element of non-conformity in the values of cart-load reported by cultivators. The values of cartload as reported were observed to be varying between the cultivators of the same village, though, variation was smaller in magnitude (maximum difference in the value reported is Rs.2/-

per cart-load), and, therefore, could be explained in terms of subjective valuation of the quality of the manure by the cultivators.

However, when average value for cartload of farm-yard manure is computed at the village level (average of values reported by sample cultivators of the same village), there were large variations in the average values of different villages.

For example, while the average value of cart-load of farm yard manure for sample village Parunde was Rs.4.77 and that for Shinoli, Rs.6.60, it was as high as Rs.10.40 for Chikhali and Rs.9.50 for Phursungi. Thus, while the difference in the values reported by cultivators of the same village was Rs.2/- and less, as stated above, the difference in average values for villages was even more than Rs.5/-, which could not be explained as arising out of subjective valuation of farm yard manure by the cultivators. Apart from this, there was a definite trend in average values of cart-load of farm yard manure for sample villages which is discussed below.

As stated above, average values of cartload of farm yard manure for villages Parunde and Shinoli had worked out to be Rs.4.77 and Rs.6.60, respectively, whereas in respect of Chikhali and Phursungi, they were Rs.10.40 and Rs.9.50, respectively. It is pertinent to note that while the former two villages were interior villages with respect to distance from town or state/ national high ways, the latter two were situated on the outskirts of Poona City. Average values of cartload of farm yard manure for other villages were in between these two extreme values. These other villages were either located on State-highways or near taluka headquarters. These average values of cartload of farm yard manure are indicated below in bracket against the name of the village : Narayangaon (Rs.9.40), Dawadi (Rs.8.26), Vadgaon (Rs.8.13), Walunj (Rs.8.11), Shivari (Rs.8.00), Ratwadi (Rs.7.57), Mahalunge (Rs.7.40), Narodi (Rs.7.38) and Ranjangaon (Rs.6.92).

Thus, it appears from sample data that there is some relationship between the location of the villages and the average values of cartload of farm yard manure for village.

<u>Depreciation on value of bullocks</u> : As in the case of engine and motor, in case of bullocks also straight line method of depreciation is adopted for computing depreciation charges. In the course of survey, cultivators were asked to state the value of each of their owned bullocks and its expected life.

In Table 6.9, we present the distribution of total bullocks owned by cultivators by their reported values and lives.

It may be mentioned here that since pair or pairs of bullocks were not reserved specifically for operation of mhot by cultivators, we have computed maintenance costs for all

Table 6.9 : Distribution of bullocks according to their value on date and expectancy of life.

Value of bullocks (In Rs.) / Expected life in years	No.of bullocks										Total no.of bullocks
	1	2	3	4	5	6	7	8	9	10	
0-200	1	3	-	-	2	-	-	-	-	-	6
201-400	-	2	-	45	49	38	16	12	-	-	162
401-600	-	-	-	-	4	6	5	10	-	8	33
601-800	-	-	-	-	-	-	-	2	-	-	2
Total no.of bullocks	1	5	-	45	55	44	21	24	-	8	203

the owned bullocks of the cultivator and then apportioned the cost for irrigation purposes in the ratio of bullock-days utilised for irrigation purposes to total working days in a year.

As normally expected, the table 6.9 shows somewhat positive relationship between the value of bullock reported by cultivator and its life. However, there are other significant factors affecting value of a bullock, such as, breed, size and health conditions of the bullock which are not accounted for in our data.

Cost of feed and concentrates given to bullocks : The main constituent of the total cost of maintenance of a bullock in a particular year is the cost of feed and concentrates given to bullocks.

The sample cultivators were asked to state the details of feed and concentrates given to bullocks daily and their values. It may be observed here that although the details were collected of quantities of different straw bundles (jowar, bajra, rice) oil-cake, and other local feed like "Bhuusa" (husk), lucerne grass, it is not possible to present all the details feed-wise here because inter-cultivator comparison of a particular feed given to bullocks cannot be made. Even the values of straw bundles varied from cultivator to cultivator, depending upon the length of straws and its number in the bundle. The same is true with lucerne grass which was reported in terms of "bharas" or heaps, the size of each heap varying from cultivator to cultivator.

However, it may be noted that most of the feed was self-produced and none of the sample cultivators reported having bought the feed from the market except the oil-cake. Hence, an attempt is made below to see whether any relationship exists between the reported expenditure incurred on feed per bullock and the size of bullock holding of a cultivator. The underlying assumption being as the feed is mostly from one's own farm, per bullock expenditure would be less for a given cultivated holding if the bullock-holding is more. In other words, per bullock expenditure on feed would be less for a cultivator who has larger bullock-holding than for a cultivator who has smaller bullock-holding if both the cultivators have roughly the same cultivated holding.

In Table 6.10, distribution of cultivators by bullock-holding and by size of expenditure incurred per bullock is presented : Additionally, we have also provided average size of cultivated holding for each size-group of bullock-holding so as to find out whether the difference in the expenditure per bullock can be explained by difference in the average size of cultivated holding.

Table 6.10 : Distribution of cultivators by size of their bullock holding and expenditure incurred per bullock on fodder and concentrates.

Per bullock expenditure size-group (In Rs.)	Distribution of sample cultivators by size of bullock holding as under									
	1 bullock		2 bullocks		3 bullocks		4 bullocks		5 bullocks	
	No. of sample cultivators	Average cultivated holding	No. of sample cultivators	Average cultivated holding	No. of sample cultivators	Average cultivated holding	No. of sample cultivators	Average cultivated holding	No. of sample cultivators	Average cultivated holding
0-300	-	-	5	8.630	1	8.175	5	16.717	1	17.000
301-600	1	12.350	20	12.174	-	-	15	14.827	-	-
600 & above	-	-	-	-	-	-	2	18.250	-	-
Total	1	12.350	25	11.465	1	8.175	22	15.568	1	17.000

	6 bullocks		7 bullocks		8 bullocks		Total	
	No. of sample cultivators	Average cultivated holding	No. of sample cultivators	Average cultivated holding	No. of sample cultivators	Average cultivated holding	No. of sample cultivators	Average cultivated holding
0-300	-	-	-	-	-	-	12	12.659
301-600	8	17.888	-	-	1	25.000	45	15.021
600 & above	-	-	-	-	-	-	2	18.250
Total	8	17.888	-	-	1	25.000	59	14.148

Note: Cultivated holding acres.

To some extent, table 6.10 reveals positive relationship between the expenditure incurred on bullock and the average size of cultivated holding of the cultivator as can be seen from the last column of the table. Similarly, it can be observed from the table, that within the same per bullock expenditure size-group, average size of cultivated holding increases with increase in bullock holding as if to sustain same level of expenditure.

However, the relationship between per bullock expenditure and size of holding is not perfect. For instance, it can be observed that even with smaller cultivated holding, some cultivators (15 cultivators having 4 bullocks) have incurred higher expenditure per bullock than the cultivators having same number of bullocks and bigger cultivated holding. These exceptions are mainly due to greater proportion of concentrates like oil-cake, etc. (which were purchased in the market) in the total feed given to bullocks.

Cost of human labour : As stated earlier, cost of human labour involved in the operation of mhot is taken into consideration as part of total cost of this mode of irrigation. Out of 59 sample lifts, in respect of 57 lifts, one person's cost is taken into account. For the remaining 2 sample lifts, 2 persons' cost in each case is taken into consideration, since these lifts involved operation of 3 mhots simultaneously, thus requiring supervision of 2 persons. As the wage rate is normally expressed for working day, the hours of operation of mhot were converted into days at the rate of 8 hours a day.

As stated earlier, prevailing daily wage-rate for casual labour in the village is considered for computing cost of human labour involved in operation of lift, though in majority of cases, the cultivator or his family members were operating the mhot.

Except three villages namely, Phursungi, Chikhali and Narayangaon, in all other sample villages, the daily wage rate for casual labour was reported to be Rs,3/-.

In Phursungi and Chikhali, it was reported to be Rs.4/- while in Narayangaon it was reported to be Rs.3.50. It may be again observed that Phursungi and Chikhali being situated near Poona city, it was natural to expect higher casual labour charges in these villages. Narayangaon, though away from Poona city, was situated on National highway, and more than that, in its nearby village, Government of India had then undertaken the construction of Tele communication centre which provided employment to many villagers, thus pushing up the wage rate.

Costs of Irrigation by bullock lift.

Table 6.11 depicts costs of irrigation by bullock-operated lift at various levels of operation in terms of pair-hours,

Table 6.11 : Costs of irrigation by bullock-lift. In (Rs.)

Pair-hours of operation during the year (In size-group)	No.of lifts	Average no.of pair-hours	Cost of irrigation per lift			Cost per pair hour of operation
			Total	Fixed	Variable	
0-400	23	189.56	278.80 (100.0)	46.25 (16.59)	232.55 (83.41)	1.47
400-800	14	580.33	699.17 (100.0)	35.81 (5.12)	663.36 (94.88)	1.20
800-1200	9	950.89	1120.19 (100.0)	23.62 (2.11)	1096.57 (97.89)	1.18
1200-1600	5	1472.40	1494.82 (100.0)	20.25 (1.35)	1474.57 (98.65)	1.02
1600-2000	4	1730.50	1923.97 (100.0)	14.40 (0.75)	1909.57 (99.25)	1.11
2000-2400	4	2188.88	2282.40 (100.0)	16.70 (0.73)	2265.70 (99.27)	1.05
Total	59	746.88	857.32 (100.0)	33.95 (3.96)	823.37 (96.04)	1.15

Note : Figures in brackets indicate share (in percentage) in total.

during the reference period. To bring out the trend in costs of irrigation at various levels of operation, the number of hours of operation of sample lifts has been clubbed in different size-groups. For each size-group, component-wise costs of irrigation and cost per pair-hour of operation are presented in above table.

For the purpose of presentation of component-wise cost of irrigation, fixed costs have been taken to include cost of wooden structure and mhot wherever lasting for more than one year. The following conclusions emerge out of table 6.11 :

(i) At higher level of utilisation, the absolute amount of fixed cost tends to decline, thus showing fast wearing of mhots employed for lift purposes and consequently, the mhots being classified as variable costs.

(ii) Predominance of variable costs in total costs is seen at all levels of operation. The share of variable costs in totals cost rises with the increase in level of operation. However, it is important to note that since absolute amount of fixed cost is very small, economies of scale at higher levels of operation through distribution of fixed costs over larger number of hours of operation are not perceptible. On the other hand, the accrual of economies of scale are through greater utilisation of some of the high-priced items of variable costs such as mhot and accessories attached to mhot.

(iii) Cost per pair-hour of operation tends to decline upto 1600 pair-hours of operation and gradually rises thereafter. This is due to greater utilisation of lifts largely consisting of one mhot upto 1600 pair-hours of operation and less than optimum utilisation of lifts consisting of

2 and 3 mhots each beyond 1600 pair-hours of operation.

(iv) Considering the multifarious uses of bullocks and low irrigational requirements during 4 months of Kharif season covered by the Monsoon, the last size-group of pair-hours (2000-2400) reflects maximum hours of irrigation during the year, since even with deployment of 3 pairs of bullocks for irrigation purposes, it worked out to 100 days of irrigation in a year.

Cost functions fitted for bullock-operated lift conform to the above-mentioned trend of pair-hour cost of operation.

Cost Function :

As in the case of electric motors and oil engines, in respect of bullock-operated lift also, we have fitted cost functions, taking pair-hours of operation as independent variable and cost per pair-hour of operation as dependent variable. Both, double log function and quadratic function, were attempted and the results of these fits are presented in Annexure 6A. It may be observed from the results of these fits that double log is a better fit of the two, since it explains larger percentage variation than that explained by quadratic fit. Further, values of 't' and 'F' were found highly significant for double log function.

The shape of the curve (graph presented in Annexure 6B) is not as asymptotic to both the axes as in the case of curves of electric motor and oil engine. Thus the slope of the curve is less steeper than those of electric motor and oil engine, which is evident from the value of 'constant' in the fitted function. This is mainly because of predominance of variable costs in total costs of irrigation at all levels of operation.

The shape of the curve when compared to those of electric motors and oil engines might create an impression that it is economical to use bullock-operated lift rather than oil engine, even at higher levels of operation. However, it may be stated here that per pair-hour cost of bullock-lift and per hour cost of other mechanised lifts are not comparable due to large differences in their discharge capacities. An attempt is made in the following chapter to standardise their hours of operation taking into account the indicator of discharge capacities so that the costs of different modes at various levels of operation can be compared.

ANNEXURE 6A

COST FUNCTION

I. Double log function - bullock operation lift.

Number of observations = 59

x - Independent variable - pair hours of operation (In log)

y - Dependent variable - cost per pair hour of operation (In Rs.) (In log)

	Coefficient	t-test
Constant (log a)	1.5455	
Regression Coefficient (b)	-0.2086	10.33 t_{60}=1.96 at 5% level (normal table)

Analysis of Variance

Source	Degrees of freedom	Sum of squares	Mean E.S.S.	F-test
Regression	1	3.3641		106.71
Error	58	1.8284	.0315	$F_{1,60}$=4.00
Total	59	5.1925		at 5% level (table value)

$r^2 = 0.6479$

Percentage variation explained = 64.79

Function : $\log y = \log a + b \log x$

Fitted function : $\log y = 1.5455 - 0.2086 \log x$

$$y = 4.622x^{-.2086}$$

II. Quadratic Function - Bullock operated lift.

Number of observations = 59

x = Independent variable - pair-hours of operation.

y = Dependent variable - cost per pair-hour of operation.

		Coefficient	t-test	
Constant (a)		1.9792		
Regression)	b_1	-0.0015	5.76)	t_{60} = 1.96 at 5% level (normal table)
coefficients)	b_2	0.0000005	4.82)	

Analysis of Variance

Source	Degrees of freedom	Sum of squares	Mean E.S.S.	F-test
Regression	2	6.4783		25.37
Error	57	7.2789	0.1277	$F_{2,60}$=3.15 at 5% level
Total	59	13.7572		(Table value)

$r^2 = 0.4709$

Percentage variation explained = 47.09

Function : $y = a + b_1x + b_2x^2$

Fitted function : $y = 1.9792 - 0.0015\ x + 0.0000005x^2$