INTER-REGIONAL COMPARISON OF FARM LABOUR PRODUCTIVITY AS REVEALED THROUGH THE "STUDIES IN THE ECONOMICS OF FARM MANAGEMENT"

BY

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CERTIFICATE

This is to certify that the thesis entitled "Inter-regional Comparison of Farm Labour Productivity as Revealed Through the "Studies in the Economics of Farm Management" submitted in partial fulfilment of the degree of Master of Science in Agricultural Economics by Shri K. N. Syamasundaran Nair, embodies the results of a bonafide research work carried out by him, under my guidance and supervision. No part of of this study reported here have so far been submitted anywhere for publication or for any other degree or diploma. It is further certified that such help or source of information as has been availed of during the course of investigation has been duly acknowledged by him.

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CHAPTER I

INTRODUCTION

Human labour and bullock labour together constitute almost half of the total cost of the inputs used in crop production. Since much of the farm labour is generated within the farm, it is fixed and hence assumes added significance. Given the technology, the fixed nature of these assets in the business partially determines the productivity of the resources and the nature of the returns to scale. Further, the operation of the 'Law of Diminishing Returns' begins already in the range where a large proportion of assets is fixed and that too at low levels of use. The present study is an attempt to measure the productivity of two important resources of the Indian farming namely, human labour and bullock labour.

The land-man ratio of the agricultural sector existing in different states can give a rough indication of the comparative nature of farm labour productivity. But as agro-climatic conditions, cropping patterns, crop yield rates, resource endowments etc. differ from region to region in the country, marginal productivity of labour at the mean level of inputs can provide a better estimate of labour productivity. It can also be used to compare labour productivity between regions and in various crop enterprises. The low productivity of human labour in Indian Agriculture, due to heavy pressure of population and low level of technology is well known and widely accepted. However, precise knowledge about how low these levels of productivity are, is not available and can be accomplished

only if studies oriented to that end are undertaken. In view of the regional variations, an understanding of the marginal productivity of labour in agriculture is of crucial importance in making decisions concerning the desirability of developing additional employment opportunities, in choosing the form of these opportunities, and in planning their location. Further, it is quite likely that shifting of resources even within the farm, from one crop to another, may raise the productivity of labour.

Some studies[1] have been made on the relationships of the size of holding and productivities of human labour and bullock labour. Few attempts have been made to compare the marginal productivities of these inputs for various crops within the region and between different regions. Similarly, only few attempts have been made to determine the economic optimum levels of use for human labour and bullock labour for different regions and crops. Largely, cross tabulation analyses have been done to estimate the returns from human labour and bullock labour inputs. In a few cases production function analyses have also been undertaken to determine the productivities of these inputs.

In the present study it is attempted to determine the marginal productivity of human and bullock labour inputs and their economic optimum levels for different sized farms. The size of holding has been used as an institutional variable factor in the production equation. In the 'Studies in the Economics of Farm Management' conducted by the Directorate of Economics and Statistics, Government of India, in various States, generally power functions have been used,

1. Details are given under Review of Literature in Chapter II.

whereas in the present study an effort has been made to fit polynomial functions of the second degree along with power functions mainly to study the possible negative marginal returns of labour met with in certain cases. This investigation in this sense is complementary to what has already been done in this field.

The objective of this investigation is to measure the marginal value productivity of human labour and bullock labour at different levels of other inputs in different crop enterprises in selected regions of the country. Inter-regional productivity comparisons is the principal aim of the study.

The results of this study can be made use of for individual farm decisions and national policies. An individual farm operator can benefit from this information by being able to formulate better decisions regarding resource adjustments to maximise returns from limited resources. At national level, it may help to formulate farm policies providing for a more efficient use of national resources. These results may also serve as benchmark observations for future studies, which would investigate the changes in productivity of labour occurring over time, especially with reference to changes in technology.

The first part of the study deals with a brief review of what has already been done in this country on the productivity of human labour and bullock labour and also some of the hypotheses currently propounded on the productivity of labour in underdeveloped countries. The second part deals with data and methodology. The third part deals with findings and the last part constitutes interpretations and suggestions.

CHAPTER II

A REVIEW OF LITERATURE

Relatively few studies have been undertaken in this country to determine the productivity of inputs that go into the production of various crops. The 'Studies in the Economics of Farm Management' in various states initiated by the Directorate of Economics and Statistics, Department of Agriculture, Ministry of Food and Agriculture, Government of India, is one of the comprehensive and systematic attempts in this direction. As far as the estimation of resources productivities are concerned these studies followed mainly the methods of cross tabulation analysis, correlation analysis and in a few cases regression analysis by fitting production functions.

In 1959 Driver and Desai[1] estimated the marginal productivities of human labour and bullock labour inputs for different crops in the districts of Nasik and Ahmednagar of the then Bombay State and presently in the state of Maharashtra by use of partial regression analysis. They found that the marginal value product of human labour was Rs. 1.2671 per day in dry rabi jowar in Ahmednagar district under cost accounting method and Rs.1.6553 per day

1. P.N. Driver, and D.K. Desai, Studies in the Economics of Farm Management in Bombay, Report for the year 1955-56, (1959), p. 162, 169, 174 and 178.

under the survey method. For irrigated jowar in the same district they found that the corresponding figures were Rs. 0.6907 and Rs. 1.3589 under cost accounting method and survey method respectively. They estimated the marginal value product of human labour day in wheat in Nasik district to be Rs. 2.1889 under cost accounting method. Their estimates for marginal value product of one plough unit per day in case of dry rabi jowar in Ahmednagar district were Rs. 2.4977 under cost accounting method and Rs. 2.5492 in survey sample. For irrigated jowar in the same district, the corresponding estimate was Rs. 1.3056 (cost accounting method). For dry wheat in Nasik district under cost accounting method, the estimated marginal value product of one plough unit per day was Rs. 1.7509.[3]

They reported the fitting of Cobb-Douglas type of production functions to study the productivity of different resources including human labour and bullock labour, used for various crops.[4] They could not draw any conclusions as the elasticities of production were not statistically significant.

3. Ibid., p. 190

4. P.N. Driver and D.K. Desai, Studies in the Economics of Farm Management in Bombay. Report for the Year 1956-57 p. 257-260

Ajaib Singh et al.[5] in their "Studies in the Economics of Farm Management in Punjab" estimated the marginal physical product of human labour day in irrigated wheat and American cotton by partial regression analysis. They found that for irrigated wheat it was 0.288 maunds of grain and for American cotton 0.1353 maunds of seed cotton. They found that the use of an additional unit of bullock labour would have decreased the yield of wheat by 0.122 maunds of grain and of American cotton by 0.0501 maunds of seed cotton, as the marginal productivities were negative.

Taking the data from the Studies in the Economics of Farm Management in Punjab for the years 1954-55, 1955-56 and 1956-57, Raj Krishna[6] in 1964 used Cobb-Douglas type of functions to estimate the marginal productivities of various inputs in Punjab farms. He found that the marginal value products of human labour viz. Rs. 1.19 and Rs. 1.78 at respective geometric means were relatively stable in the years 1954-55 and 1955-56 and it rose very steeply in 1956-57 to Rs.4.37. Comparing the marginal products with the actual wages of human labour he found

5. Ajaib Singh, Gurdit Singh, Swaran Singh Athwal, and N.S. Randhawa, Studies in the Economics of Farm Management in Punjab, Report for the year 1954-55, p. 90 and 121

6. Raj Krishna, Some Production Functions for the Punjab, Indian Journal of Agricultural Economics, Silver Jubilee Number, Vol. 19 Nos. 3 and 4, July-December 1964, p. 90-92

that in the first two years the marginal value product of human labour at geometric mean was less than the wage rates of Rs.2.49 and Rs. 2.59 respectively and in the third year, it was much higher than the wage rate of Rs. 2.96. He also observed that the average labour input declined substantially from 495 to 360 man days during the three years inspite of the increase in the total "earner" man power in the sample families from 464 to 532 persons and thus the rise in marginal product of labour was associated with the fact that the farmers economised labour. This, he thought might be due to the fact that in the first two years the wage rate was higher than the marginal product of labour. He concluded that the marginal product estimates "are not so widely out of line with acquisition costs as the usual references to the irrationality of the Indian peasant imply."

Basak and Choudhury[7] fitted linear functions to the data from the "Studies in the economics of Farm Management in West Bengal" to determine the production elasticities of various resources used in the production of Aman paddy and jute. They found that the productivity of human labour for both paddy and jute in manured plots was greater than in unmanured plots. They observed a similar trend for bullock labour in the case of paddy. The effect of bullock labour on the yield of jute crop was not statistically significant.

7. K.C. Basak and B.K. Choudhury, Studies in the Economics of Farm Management in West Bengal, Reports for the years 1954-55, 1955-56 and 1956-57.

Mathur and Khudanpur[8] fitted Cobb-Douglas type of functions to study the productivities of human labour and bullock labour in different crop enterprises in Madhya Pradesh. Using the 1955-56 data from the "Studies in the Economics of Farm Management", they found that the regression coefficients (elasticities of production) of human labour and bullock labour (combined into one input) were negative for 'farm business as a whole,' while in cases of jowar-urid-mung combination and cotton-tur combination these coefficients were not statistically significant.

In their study of 1956-57, they used human labour and bullock labour as separate inputs. They defined bullock labour as plough hours consisting of 2 hours of bullock labour and 1 hour of human labour. Human labour was separated into two groups viz. residual man labour hours and female labour hours. For the 'farm business as a whole,' the regression coefficients were 0.13 for plough hour, 0.26 for residual male labour and -0.13 for female labour[9]. In other cases the coefficients of these inputs were not significant statistically.

8. P.N. Mathur, G.J. Khudanpur, Studies in the Economics of Farm Management in Madhya Pradesh, Report for the year 1955-56, p. 53, 61 and 62

9. P.N. Mathur, Studies in the Economics of Farm Management in Madhya Pradesh, Report for the year 1956-57, p. 53, 63 and 66.

Zacharias[10] used Cobb-Douglas type of functions to estimate the marginal productivities of human labour and bullock labour in selected crop enterprises in the districts of Coimbatore and Salem in Madras State at different levels viz. ½, ¾, 1, 1½ and 2 times the geometric mean of the inputs. Further, he studied the changes in the marginal productivities of human labour and bullock labour, keeping other inputs at different levels namely ½, 1 and 2 times their geometric means. He found that labour productivity was a function of labour use levels but it was also a function of other inputs.

By analysing the data for 1955-56 on irrigated cotton (Season II) he found that labour productivity was a function of the quantity of labour input used and in the existing situation, the increase in this input with other inputs held contant would not be advisable.[11] Since labour productivity is also a function of other inputs, he concluded that an increase in other inputs could increase the labour producvity.[12] For 1956-57 data of the irrigated cotton (Season II), he found a similar situation; the increase in the labour input with other inputs kept constant was not advisable.[13] The analysis of the data for 1955-56 on

10. C.N.B. Zacharias, Studies in the Economics of Farm Management in Madras, Reports for the years 1954-55, 1955-56 and 1956-57.

11. Ibid., Report for the year 1955-56, p. 121 and 194.

12. Ibid.

13. Ibid. Report for the year 1956-57, p. 84, 154 and 155.

irrigated jowar (Season III) showed that there was too much of human labour already in use. While studying the 'farm business as a whole' he found that the human labour productivity appeared to increase with an increase in other inputs.

With bullock labour input also he found a similar behaviour. In irrigated jowar (Season III) he observed that the marginal productivity of bullock labour decreased as its quantity in use increased; while the marginal productivity of bullock labour increased when the level of bullock labour was kept constant and the levels of other inputs were increased.[14]

Agrawal[15] determined the marginal value product of bullock labour and human labour by fitting a Cobb-Douglas type of production function to the farm management survey data for 1954-55 in Uttar Pradesh. According to him the low values of marginal products of these inputs indicated that they are used at high levels and any addition would result in little return. He found that marginal value products of these resources increased when the input levels of other resources increased. He observed the same trend for the data of 1955-56 also. He concluded from the low marginal value products of human labour and bullock labour inputs that additional expenses on these inputs would not be advisabl

14. Zacharias, Report for the year 1954-55, Op.cit. p. 137

15. G.D. Agrawal, Studies in the Economics of Farm Management in Uttar Pradesh, Combined Report for the years 1954-57, p. 86 and 113.

He also found that the marginal value product of human labour increased when the levels of other resources were raised. While analysing the data for 1954-55 pertaining to irrigated wheat in the same study, he found that the relationship between output and the inputs of human labour and bullock labour was not significant statistically.

In Madhya Pradesh, Mathur and Khudanpur[16] found that the family labour income per acre decreased progressively with the increase in the size of holding. The family labour income per acre was Rs. 64.66 for the size group of 5 acres and below while it was only Rs. 33.14 for the size group of 50 acres and above. At the same time they found that the gross product per labour hour was more or less stable in the different size groups though within the major size groups (less than 15 acres, between 15 and 40 acres and above 40 acres) it increased with the increase in the size of holding.[17]

Zacharias[18] measured the labour productivity for 'farm business as a whole' in the districts of Salem and Coimbatore applying the widely used measurements, viz. return per worker and gross output per worker. He found that the size of farm, the cropping pattern, the fixed capital available and the amount of

16. Ibid., p. 49

17. Ibid., p. 50

18. Zacharias, Report for the year 1954-55, op.cit. p.70,71,74,

working capital expended had a bearing on the quantum of return. He observed that the returns per worker were the lowest in the smallest size group and increased as the size of farm went up. When he related the return per farm worker with capital available (both fixed and working) he observed that broadly the former increased with an increase in the latter. The study made on the cropping pattern revealed that the return per worker were greater on the holdings growing commercial crops than those growing food crops only.[19] By analysing the data for the year 1955-56 he showed that holdings which were fully rented gave the least return per worker.[20] He also found that unirrigated holdings gave the lowest return per worker when compared to fully irrigated or partially irrigated holdings.[21] These findings led him to the conclusion that the return per worker could be increased appreciably by enlarging the size of the farm, by growing non-food crops along with food crops, by increasing the available irrigational facilities, and by making the tiller feel that the piece of land cultivated by him was his own.

Zacharias[22] tried to measure the efficiency of labour on the cultivated area per man equivalent and work units per man equivalent. He found that the cultivated area per man equivalent increased steadily with the increase in the size of farm. Similarly,

19. Zacharias, Report for the year 1954-55, op. cit., p. 72
Zacharias, Report for the year 1955-56, op. cit., p. 65

20. Ibid.

21. Zacharias, Report for the year 1956-57, op. cit., p.65

22. Zacharias, Report for the year 1954-55, op. cit., p. 76

he saw that the number of work units was least in the smallest size group and the greatest in the largest size group. He further observed that a farmer in the largest size group did 1.6 times the work done by his counterpart in the smallest size group.

Several workers have tried to relate size of holding with employment of human labour, hired human labour, permanent working unit, and input per acre of human labour.

Driver and Desai[23] found that the employment of human labour was almost directly related to the size of the farm. The smaller the farm lesser was the employment for the operator himself. Ajaib Singh et al.[24] found that larger the holding greater the number of days put in by a permanent farm worker. In a similar study Zacharias[25] found that the employment on the farm steadily increased as one passed from the lowest to the highest size groups. While studying the paddy crop enterprise Agrawal[26] found no statistically significant relationship with human labour utilization and size of farm.

The studies of Ajaib Singh et al. Punjab farms and of Basak and Choudhury[27] in Bengal farms showed that the proportion of hired labour increased with the size of holding. Surprisingly, Mathur

23. Driver and Desai, Report for the year 1954-55, op. cit.,p. 52
Driver and Desai, Report for the year 1955-56, op. cit.,p. 82
Driver and Desai, Report for the year 1956-57, op. cit.,p. 82

24. Ajaib Singh et al., Report for the year 1954-55, op. cit., p. 52 and 75.

25. Zacharias, Report for the year 1954-55, op. cit., p. 36

26. Agrawal, Combined report for the years 1954-57, op. cit., p. 142

27. Basak and Choudhury, Report for the year 1955-56, op. cit., p.29

and Khudanpur[28] found that hired labour per acre was highest in the smallest size group and progressively decreased as the size increased upto the size group of 20 - 30 acres and above this size group the proportion of hired labour showed upward trend. They attributed this behaviour to the fact that some farmers in the small holdings largely depend upon hired labour as they themselves are busy with other means of livelihood. Their study also revealed that the permanent working units per farm increased from 1.70 to 6.67 as the size of farm increased while the incidence of the same per acre decreased from 0.58 per acre in the smallest group to 0.06 per acre in the highest size group.

In general, the Studies in the Economics of Farm Management in various states showed that the labour input per acre declined as the size of holding progressively increased. Driver and Desai[29] in Maharashtra found that the size of holding and input of human labour per acre was negatively correlated. Ajaib Singh, et al.[30] found the same trend in Punjab farms except in the desi cotton enterprise where they noticed some tendency for labour (both family and exchanged and hired) to increase with the increase in the size of holding. On West Bengal farms Basak and Choudhury[31] found that the input of human labour per acre

28. Mathur and Khudanpur, Report for the year 1955-56, op. cit., p. 20 and 49.

29. Driver and Desai, Report for the year 1955-56, op. cit., p. 114

Driver and Desai, Report for the year 1956-57, op. cit., p. 119

30. Ajaib Singh, et al., Report for the year 1954-55, op. cit., p. 78 and 127.

31. Basak and Choudhury, Report for the year 1954-55, op. cit., p. 4

was highest in the lowest size group and it went down with the increase in the size of farm. As regards human labour (both family and hired) per acre in Madhya Pradesh farms Mathur and Khudanpur[32] found that it went on decreasing as the size of holding increased. In Madras farms, Zacharias[33] found a similar trend where the human labour input per acre was largest in the smallest size group and the human labour input declined as the size increased. Agrawal[34] found, in Uttar Pradesh farms, that the input of human labour per acre was highest in the smallest size group but declined as the size increased though the downward trend was not pronounced. He found a similar trend in individual crop enterprises like sugarcane (ratoon) where the decrease was clear as the size of holding increased while in wheat both irrigated and unirrigated, the difference was meagre.

In Bombay state Driver and Desai[35] and in Uttar Pradesh Agrawal[36] worked out the correlation between the input of human labour and output per acre for the individual crop enterprises and found that they were positive.

32. Mathur and Khudanpur, Report for the year 1955-56, op. cit.,p. 49
33. Zacharias, Report for the year 1954-55, op. cit., p. 66
    Zacharias, Report for the year 1955-56, op. cit., p. 52
    Zacharias, Report for the year 1956-57, op. cit., p. 56
34. Agrawal, Report for the year 1956-57, op. cit., p. 32 and 51
35. Driver and Desai, Report for the year 1956-57, op. cit., p. 159-2
36. Agrawal, Report for the years 1954-57, op. cit., p. 129

Using the same data Driver and Desai[37] studied the relationship of size of farm and employment of bullock labour in relation to yearly availability on Maharashtra farms. They found that employment increased from 50.52 per cent to 66.14 per cent of yearly available as the size of the farm went up from 2.5 acres to 100 acres and above. When bullock labour for farm work only was taken into consideration, the difference was more pronounced, the employment of bullock labour increasing from 23.62 per cent in size group 2.5 acres to 53.82 per cent in size group 100 acres or more. The data for 1956-57 also indicated a similar trend. On account of larger employment of bullocks by the farmers in hired work the trend regarding unemployment was not so marked as the trend on the employment of bullock.[38]

In their study on Punjab farms Ajaib Singh et al.[39] found that bullocks in the largest holding size group puts in 2½ times more work than bullocks belonging to cultivators in the smallest size group. Basak and Choudhury[40] found that the employment was lowest and hence wastage of bullock labour was highest in the smallest size group among West Bengal farms. On Madhya Pradesh Pradesh farms Mathur and Khudanpur[41] saw the best utilization of

37. Driver and Desai, Report for the year 1954-55, op. cit., p. 211
Driver and Desai, Report for the year 1955-56, op. cit., p. 97
38. Driver and Desai, Report for the year 1956-57, op. cit., p.109
39. Ajaib Singh et al., Report for the year 1954-55, op.cit.,p. 54
40. Basak and Choudhury, Report for the year 1955-56, op. cit. p. 32
41. Mathur and Khudanpur, Report for the year 1955-56, op. cit., p. 24

bullock labour in the size group of 10 - 15 acres. On Madras farms, Zacharias[42] found that the employment of bullock labour was high in the largest size group being 1.5 times the average. In the sugarcane enterprise on Uttar Pradesh farms Agrawal[43] noticed little variation in the utilization of bullock labour between different size groups.

Driver and Desai[44] also studied factors other than size that affected bullock labour employment in Bombay farms. Their studies showed that the availability of irrigation was one factor because employment was only 16.30 per cent in unirrigated farms while it was 51.23 per cent in partially irrigated farms. Further they found that size of holding combined with irrigation had particularly significant effect on employment of bullock labour as it rose from 3.95 per cent to 25.54 per cent in purely irrigated farms and from 23.61 per cent to 65.87 per cent in irrigated farms as the size of holding moved up from 2.5 acres to 75 - 100 acres size group.

Several workers have studied the relationship of bullock labour input per acre with the size of farm. In Maharashtra Driver and Desai[45] found that bullock labour input per acre in farms below 20 acres was larger than for farms above this size. In the 1956-57 data, they saw a more pronounced trend of decrease in

42. Zacharias, Report for the year 1955-56, op. cit., p. 40
43. Agrawal, Combined report for the years 1954-57, op. cit., p. 103
44. Driver and Desai, Report for the year 1954-55, op. cit., p. 211
45. Driver and Desai, Report for the year 1955-56, op. cit., p. 115

bullock labour input per acre as size of holding increased.[46] Ajaib Singh, et al.[47] in their studies of Punjab farms, however, found that the input of bullock labour per acre increased with the size of holding when farm business as a whole was considered. They saw a similar trend in unirrigated wheat-gram mixture. No definite variation was found in irrigated wheat while in the irrigated wheat-gram mixture and desi cotton the trend was that of an increase in the size of holding accompanied by an increase in the bullock labour input per acre. In Madhya Pradesh, Mathur and Khudanpur[48] showed that bullock labour input per acre was not influenced by the size of holding, but the highest input use per acre was found in the smallest size group and it progressively diminished until it stabilised for the size groups exceeding 15 acres. Zacharias[49] found that the relationship was negative for Madras farms. He found that the input per acre increased considerably more on irrigated farms. On Uttar Pradesh farms

46. Driver and Desai, Report for the year 1956-57, op. cit., p. 120

47. Ajaib Singh et al., Report for the year 1954-55, op. cit., p. 78, 88, 101, 110 and 128.

    Ajaib Singh et al., Report for the year 1956-57, op. cit., p. 88 and 89.

48. Mathur and Khudanpur, Report for the year 1955-56, op.cit., p. 49

    Mathur, Report for the year 1956-57, op. cit., p. 18 and 43.

49. Zacharias, Report for the year 1954-55, op. cit., p. 66

    Zacharias, Report for the year 1955-56, op. cit., p. 52

    Zacharias, Report for the year 1956-57, op. cit., p. 56 and 72

Agrawal[50] found that the input of bullock labour per acre decreased significantly with the increase in the size of farm. However, in gram the decline was only slight while in sugarcane and paddy no marked trend in the relationship was seen. The studies conducted in Delhi villages by the Division of Agricultural Economics of the Indian Agricultural Research Institute, New Delhi have demonstrated that bullock labour inputs per acre increased with increase in size of holding.[51] Also, in all size-groups, taking 'farm business as a whole,' the availability of assured irrigation supply helps to even out the peaks and troughs in bullock labour use as contrasted with unirrigated farms where there are periods of pronounced rise and slump in bullock labour use.

Zacharias[52] in Madras farms and Agrawal in Uttar Pradesh farms showed that the cost per unit of bullock labour decreased progressively as the size of the holding increased.

Zacharias[53] measured the efficiency of bullock labour input in Madras farm on the basis of area commanded by a pair of bullocks. He found that the area commanded increased as one moved from smaller to larger size group though the increase was less than proportionate to the increase in size.

50. Agrawal, Combined report for the year 1954-57, op. cit., p. 57, 69, 70, 103, 112, 123, 136, 142, and 143.

51. T.P.S. Chawdhari et al., "Studies in the Economics of Farm Business on Cultivators' holdings in Kanjhawla Block, Delhi Territory 1959-60 to 1961-62" (Unpublished)

52. Zacharias, Report for the year 1955-56, op. cit., p. 40

53. Zacharias, Report for the year 1954-55, op. cit., p. 40

Zacharias, Report for the year 1956-57, op. cit., p. 46

Driver and Desai[54] found that the input of human labour and bullock labour were highly correlated on Maharashtra farms. Ajaib Singh[55] et al. found the same on Punjab farms. Rajkrishna,[56] in his analysis of the data from Punjab, found that bullock labour input was highly correlated with land, manual labour and operating expenditure.

In their study of inter-farm differences in Kumuda-Valli village, Parthasarathy and Meenakshi Malya[57] estimated that for the top group of farmers (with annual incomes above Rs. 500 per acre), the marginal productivity of human labour was negative (Rs -1.7120) indicating that input of labour above a certain level results in negative productivity. In fact they also found that the use of labour was very high in this group.

Randhawa[58] (1960) while analysing the causes of the phenomenon that increase in the farm size was not accompanied by increase in the output per unit of land, pointed out that gross as well as net productivity per productive man day showed a persistent tendency to rise as the farm size increased. With the help of

54. Driver and Desai, Report for the year 1955-56, op. cit., p. 161

55. Ajaib Singh et al., Report for the year 1954-55, op. cit., p. 90

56. Rajkrishna, op. cit., p. 89

57. G. Parthasarathy and M. Meenakshi Malya, "Inter-farm Productivity Difference - A Case Study in Kumudavalli Village," Agricultural Situation in India Vol. 15, No. 1, April 1960, p. 25.

58. N.S. Randhawa, "Returns to Scale in Cooperative Farming," Agricultural Situation in India Vol. 15 No. 4, July 1960, p. 435

Gross productivity per productive man day was calculated by dividing the gross output by total number of productive man work days.

production function analysis he showed that in large farms the gross and net productivity was higher for human labour because of the better utilization of family and hired labour in such farms than on small ones, under the conditions obtaining.

Sharma[59] studied the relationship between gross value per acre for forecast crops and productivity per agricultural worker. His study revealed that as the number of agricultural workers per unit area sown increases, there was a tendency for the productivity per agricultural worker to show a decrease. The gross income per acre showed a rising trend. He found that for every 100 acres sown there were 23 workers in Punjab, 33 in West Bengal, 39 in Madras and 110 in Kerala. The gross incomes per acre for these states were Rs. 115.20, Rs. 167.30, Rs. 175.10 and Rs.193.7 respectively. The corresponding figures of productivity per worker were Rs. 510.00 for Punjab, Rs. 467.80 for West Bengal, Rs. 449.40 for Madras and Rs. 176.20 for Kerala. He argued that given the economic resources, more and more addition of more workers increases average productivity per unit of other resources but decreases the marginal contribution of human labour to gross production.

The net productivity level indicated the earning per productive man work day after allowing the cost of all the items used in the production process.

59. P.S. Sharma, "Agricultural Productivity vis-a-vis. Productivity of Agricultural Workers During 1956-1959,"6Agricultural Situation in India. Vol. 16, No. 5, Annual Number 1961, p. 486-490.

Forecast crops are those for which the Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India, make estimates of area and production periodically. It includes almost all important food crops and cash crops. It excludes plantation crops like tea, coffee and rubber and various fruits and vegetables.

Using the data from the Studies in the Economics of Farm Management in various states Hari Prakash[60] found significant differences in per acre input of labour in the different regions. According to him these variations were explainable to a considerable extent in terms of the factors underlying them. The factors, he suggested were cropping pattern, irrigation, size distribution of holding, availablity of human labour.

Radhakrishna[61] studied the difference in the productivities of labour in two different regions of West Godavari district in Andhra Pradesh. Using regression analysis (Cobb-Douglas type function), he determined the marginal productivities of human labour and bullock labour. In Region-I-the deltaic region with a highly specialised mono-crop farming in paddy, the marginal value products per man-day of human labour and a pair of bullock labour were found to be less than the wage rate.

In his study of resource productivities in the three regions namely Thelangana, Marathwada and Karnataka of former Hyderabad state, Hanumantha Rao[62] indicated that marginal productivity of farm labour was positive and significant. He found that the elastici of production with respect to labour for the average farm was higher than for land over the whole range of farms particularly

60. Hari Prakash, "Regional Variation in Labour Inputs per acre," Indian Journal of Agricultural Economics, Vol. 17, No. 3, July-September 1962 p. 73.

61. J. Radhakrishna,"A Study of Regional Productivities of Agricultural Inputs,"Indian Journal of Agricultural Economics, Vol. 19, No. 1,January-March 1964. p. 237

62. C.H. Hanumantha Rao, Agricultural Production Functions, Cost and Returns in India, p. 24

among the unirrigated farms above 5 and 10 acres in size. He attributed the estimated high elasticity of labour, despite its abundant supply, to its functional significance in the production process. This significance, he explained, derives partly from the nonmechanized or labour intensive nature of the prevailing production techniques and partly from the relatively low level of labour use, compared to the input of land among farms of 5 and 10 acres in size, which accounted for a little over two thirds of the total cultivated area in the sample. He also found that wherever the functional significance of labour was greater and the per acre labour inputs relatively lower over a considerable area comprising large sized farms, the elasticity of output with respect to labour input was higher relative to land. Further, the elasticity of labour input was higher in unirrigated farms because the operational significance of labour was quite high in these farms. While among irrigated and partially irrigated farms, where the labour input per acre was already higher than among dry farms, the marginal significance of land rose relative to that of labour, so that the elasticity of production of land was higher.

Achari[63] estimated the productivity and investigated the allocation of resources in two samples of sugarcane farms in Queensland, Australia. The labour productivity was found below

63. T.K.T. Achari, "Resource Productivity and Optimum Resource Allocation on a Sample of Queensland Sugarcane Farms," Indian Journal of Agricultural Economics, Vol. 20, No. 2, April-June 1965, p. 21-31

ruling wage rates in almost all the functions which was explained as resulting from the seasonal nature of sugarcane farming wherein labour needs, are at a peak at planting, cultivation and harvesting time while this factor is under-employed for the remainder of the year. The labour productivity in Mackary sample was consistently low compared with the Ayr group. The possible reason given was that the former are dry farms while the latter are irrigated farms. Another observation made was that in irrigated farms the labour use was more evenly distributed throughout the year.

Mellor and Stevens[64] presented the hypothesis that 'in underdeveloped countries, under certain conditions, dominant forces appear to cause an equalising of the average product of the agricultural labour among farms and areas.' Further, the hypothesis continued, 'due to differences in production function, this leads to variations in the marginal productivity of labour among farms and areas.' They contended that in highly productive soils one may find heavy concentrations of labour and their marginal productivity is around zero if not zero itself. Under such situations, they pointed out, the labour is used beyond the point at which marginal product of labour is equal to the subsistence level. Observing the situations frequently encountered, they defended the generalisation of low marginal productivity of labour on highly productive soil and high marginal productivity of labour on relatively unproductive soil.

64. John W. Mellor and Robert D. Stevens, "The Average and Marginal Product of Farm Labour in Underdeveloped Economies," Journal of Farm Economics, Vol. 38, No. 3, August 1956, p. 780

Mellor[65] (1963) conceptualised the "Limited Aspiration model" on the use and productivity of agricultural labour in developing economies. He suggested that in most densely populated low income countries, there is a positive marginal product from additional increments of labour applied to agricultural production. However, there existed, concurrently a considerable stock of idle labour. The reasons he attributed to these phenomenon are

> ... the shape of utility surface describing the transformation of leisure into goods and services and shape and location of production possibility curves describing the same transformation.

In a traditional agriculture he argued, resources productivity is low and the rate of return to increased quantities of resources tends to be very low.[66]

> Within a traditional agriculture, changes in production are largely dependent on changes in the allocation of labour to production processes. In addition resources are combined relatively efficiently, given the economic and technical environments, so that the opportunity to increase production simply through reorganisation of production is slight.

Abundance of labour in agricultural sector and its marginal productivity is close to zero if not zero is the assumption of many workers on economic development. Lewis[67] built a model in which agriculture provides "a large pool from which recruits for the non-farm sector may be drawn with no significant decline in agricultural production." Elaborating upon the assumptio

65. John W. Mellor, The Use and Productivity of Farm Family Labour in Early Stages of Agricultural Development. Journal of Farm Economics. Vol. 45, No. 3, August 1963, p.517

66. John W. Mellor, "Agriculture in Economic Development," p. 1

67. W. Arthur Lewis, "Economic Development with Unlimited Supplies of Labour," The Manchaster School, Vol. 22, May 1954, as quoted in John W. Mellor, The Use and Productivity of Farm Family Labour in Early Stages of Agricultural Developme

in Lewis model, Ranis and Fei[68] emphasised, "the role of subsistence support" (termed the agricultural surplus) of the marginal members of the agricultural labour force whose productivity is zero or close to zero.

Jorgenson[69] contested the hypothesis of Lewis and others and built his model on the assumption of positive productivity for all agricultural labour force. He concluded that "an agricultural surplus does not exist" and went on to argue that "transfer of labour from agriculture will itself require an increase in agricultural productivity." Mellor found partial agreement with this thesis. After a study of seasonal labour cycles in an Eastern Uttar Pradesh Village, Hopper[70] indicated that marginal productivity of labour approximately equalled the going agricultural wage rate.

Mellor[71] concluded from most of the studies "lower marginal productivity of labour on farms with little land per worker than on those with substantial land per worker."

Journal of Farm Economics, Vol. 45, No. 3, August 1963, p. 517

68. Gustav Ranis and John C.H. Fei, "A Theory of Economic Development," American Economic Review, Vol. 12, No. 1, February 196 , as quoted in John W. Mellor, "The Use and Productivity of Farm Family Labour in Early Stages of Agricultural Development," Journal of Farm Economics, Vol. 45, No. 3, August 1963, p. 517.

69. Dale, W. Jorgenson, "The Development of a Duel Economy," Economic Journal, Vol. 71, June 1961 as quoted in John W. Mellor, "The Use and Productivity of Farm Family Labour in Early Stages of Agricultural Development," Journal of Farm Economics, Vol. 45, No. 3, August 1963, p. 517.

70. W. David Hopper, "Seasonal Labour Cycles in an Eastern Uttar Pradesh Village," Eastern Anthropologist, Vol. 8, No. 3 and 4, as quoted in John W. Mellor, "The Use and Productivity of Farm Family Labour in Early Stages of Agricultural Development," Journal of Farm Economics, Vol. 45, No. 3, August 1963, p. 517.

71. John W. Mellor, op. cit., p. 513

CHAPTER III

HYPOTHESES

In the light of general knowledge about the problems of regional variations in labour productivity, concepts from economic theory and conclusions drawn from the review of relevant literature, the following hypotheses are proposed to be tested in the thesis. The presentation of the hypotheses is followed by the set of assumptions under which these hypotheses would be expected to hold.

1. Marginal value products of human labour and of bullock labour vary from region to region and from crop to crop within the region.
2. Marginal value product of human labour is affected by size of holding, quantity of bullock labour used, quantity of fertilizers used and percentage of area under irrigation.
3. Marginal value product of bullock labour is affected by size of holding, quantity of human labour used, quantity of fertilizers used and percentage of area under irrigation.
4. The marginal value product at geometric mean level is different from the prevailing price of the factors and therefore is different from the economic optimum level of human labour and bullock labour.

CHAPTER IV

ASSUMPTIONS

1. The data on input-output relationship collected in the Studies in the Economics of Farm Management are representative of their regions.

2. The cost of bullock labour days for the size group which is near to geometric mean level of size of holding in that region is fairly representative of the price of bullock labour per day.

3. The wage rates and the prices of other inputs and outputs used in the Farm Management Studies are fairly representative for the regions studied.

4. The technology of farms in the regions studied have not changed during the period from 1954 to 1965.

CHAPTER V

THE DATA

Two types of data were required to test the hypotheses:

1. Input-output data

   a) Outputs : Gross returns from the farm business as a whole and from major crop enterprises for each holding.

   b) Inputs : Human labour, bullock labour, fertilizers and manures used, area under each crop, size of holding and area irrigated pertaining to each holding.

2. The cost per unit of inputs such as human labour, bullock labour, manures and fertilizers.

Sources and Methods of Collection of Data

The data for this study were taken from the "Studies in the Economics of Farm Management" conducted by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India. These studies were conducted in six regions of the country, namely, the States of Bombay, Madras, Punjab, Uttar Pradesh, West Bengal and Madhya Pradesh for three years, 1954-55, 1955-56 and 1956-57. In Madhya Pradesh these studies were conducted only for the last two years. The data published in the reports of these studies were found inadequate for the type of analysis envisaged in this investigation. The Directorate of Economics and Statistics was, therefore, approached and the original data for Bombay, West Bengal and Madras for the year 1954-55 and for Uttar Pradesh for 1956-57 were obtained from them.

Two districts in each of the six States were selected for the farm management investigations. In each State, the districts selected were contiguous and represented the important and typical soil crop complexes in the areas and some of the major cropping patterns in the country. The districts and the major crops selected are given in Table 1.

TABLE 1

STATES, DISTRICTS AND MAJOR CROPS SELECTED FOR FARM MANAGEMENT INVESTIGATIONS

State	Districts	Crops
Bombay	Ahmednagar, Nasik	Wheat, Jowar and Bajra
Madhya Pradesh	Akola, Amraoti	Jowar, Cotton and Groundnut.
Madras	Salem, Coimbatore	Paddy, Jowar and Cotton.
Punjab	Ferozepur, Amritsar	Wheat and Cotton
Uttar Pradesh	Meerut, Muzaffarnagar	Wheat and Sugarcane
West Bengal	24-Parganas, Hooghly	Paddy and Jute

Source: Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India, Studies in the Economics of Farm Management in Bombay, Report for the year 1954-55, March 1957, p. (iii).

These studies were not confined to the selected crops only. They covered the whole farm business and therefore included all the farm enterprises. Not all crops were grown on all farms, and because of this the observations included in the individual analysis change between those concerned with the 'farm business as a whole' and with individual crops.

A multi-stage stratified random sampling design was adopted with the village as the primary unit and the holding as the ultimate unit. The procedure adopted was as follows: In each region, two districts were selected for the study. And in each district ten villages were covered by cost accounting method and another ten villages were covered by the survey method. Four of these villages were common to both the methods. Thus effectively, 16 villages in each district (32 in each region) were selected for the study. In order to select the village, the district was divided into two zones homogenous with regard to agriculture and climatic conditions. From each zone eight villages were selected at random with probability proportional to cultivating population as given in the Census Hand Book; except in Uttar Pradesh where villagewise geographical area instead of population was made the basis of stratification due to non-availability of relevant population data at the time of starting the enquiry. Ten holdings were selected from each village for the cost accounting method. Twenty holdings were selected from each of the 10 villages covered by the survey method. Thus, in each region 200 holdings under the cost accounting method and 400 holdings under the survey method were included in the study[1]. The operational unit comprising all lands cultivated by the farmer irrespective of the location and ownership was taken as the ultimate unit. A preliminary enumeration of all the households was made in the selected village and the area operated by all

1. It may be noted that 8 villages in each region were common to cost accounting method as well as survey method. Therefore from each of these villages 30 holdings were selected; 10 for cost accounting method and 20 for survey method.

the cultivating households during the previous agricultural year was noted. The holdings were then ranked in descending order according to their sizes. The total number of holdings was divided into five groups, each containing an equal number of holdings. Two holdings under cost accounting method and four under survey method were selected ultimately from each group at random with equal probability. Six holdings were common to both cost accounting method and survey method villages. The villages were selected by the Directorate of Economics and Statistics and the holdings were selected by the officers-incharge of the scheme in various states.

One fieldman was posted in each one of the villages under the cost accounting method so that he could get complete records of the day to day operations and transactions of the 10 holdings selected for the study. The work of the fieldmen was supervised by a supervisor having a group of five villages under him. Exhaustive and comprehensive schedules were prepared to collect the relevant data.

The names of the districts and crops covered by the study are given in Table 2.

For the purpose of this study only the data collected by the cost accounting method were used as they were likely to reflect the situation more correctly.

TABLE 2

STATES, DISTRICTS AND CROPS INCLUDED IN THE STUDY

State	Year	Districts	Crops
Bombay	1954-55	Ahmednagar and Nasik	Wheat and Jowar
Uttar Pradesh	1956-57	Meerut and Muzaffarnagar	Wheat and Sugarcane
West Bengal	1954-55	Hoogly and 24-Parganas	Paddy and Jute
Madras	1954-55	Coimbatore and Salem	Paddy, Jowar and Cotton

Adjustments Made in the Data

Though broadly there exists uniformity in the data collected in various regions by the Directorate of Economics and Statistics in their Farm Management Studies, considerable variation is seen in details especially with respect to items included in the returns of the farm. For example in Bombay, the information on returns available includes value of total products, dairy products and others. The returns from crop enterprises were, therefore, obtained by deducting the value of dairy products and other products from the value of total products. Similar technique was used for Uttar Pradesh and West Bengal. For other states such as Madras, the data on returns of crop enterprises were available as such in the Farm Management Studies, so no indirect methods for its calculation were needed.

The returns were not taken in physical units as it was not possible to have a standard unit, for all types of crop-products and bye-products for comparison purposes. Hence on the returns side, the value of the crop products and bye-products was taken.

Since the inputs of human labour and bullock labour used were in physical units, i.e., in terms of human labour days, and bullock labour days respectively, the costs per unit of these inputs was necessary to estimate the levels of economic optimum. The prevailing wage rates were available from the published reports, for hired male, female and child labour for different types of farm operations such as ploughing, weeding, harvesting etc. For the sake of uniformity, the average wage rate for a hired adult male casual labour (a day of 8 hours) has been used to work out the cost of one human labour day regardless of the nature of farm operations. Table 3 shows the wage rates which were used in this study for different States.

TABLE 3

WAGE RATES PREVAILING IN THE VARIOUS DISTRICTS

State	District	Wage rate (Rs.) per labour day
Bombay	Nasik	0.92
	Ahmednagar	0.96
Uttar Pradesh	Meerut and Muzaffarnagar	1.25
West Bengal	Hoogly	1.55
	24-Parganas	2.44
Madras	Coimbatore	0.95
	Salem	0.97

The hire rates for bullocks were in most cases not available. In almost all the situations the total number of bullock days (hired plus owned) used per acre was given. The cost of bullock day was calculated as follows:

$$\text{Cost of bullock day} = \frac{\text{Annual total cost of bullock labour}}{\text{Number of bullock work-days}}$$

For Uttar Pradesh, the cost per pair of bullock labour day has been worked out on the basis of maintenance cost and working cost for different size groups. The cost of bullock day for the size group which was nearest to the geometric mean for the size of holding in the region, was used for analysis. In West Bengal for the 'farm business as a whole,' such details as annual cost of maintenance and number of work bullock days for each size of holding were not available. However, the percentage of unemployed bullock labour days, the percentage of employed bullock labour days used for farm work and the annual maintenance cost per bullock were available. From the percentage of employed bullock labour, the number of work days of bullocks was calculated. Then the maintenance cost was divided by the number of work days for the corresponding size group.

The bullock work-days were obtained by deducting the unemployed work days from total days in a year. And the unemployed days were calculated as follows:

$$\text{Unemployed days} = \frac{365 \times \text{percentage of unemployed bullock labour}}{100}$$

For Madras, the costs per productive day of bullock labour for different size of farm groups were available from the published reports. No such calculations were, therefore, needed for Madras. The wage rates of bullock labour per day for different crops in various regions used in the analysis are shown in Table 4.

Another difficulty was the lack of data on the size of holding for some regions. For Bombay the data on size of holdings were not available but data on land utilization, such as net area sown and current fallows were available. Therefore, the size of holding was calculated as follows:

Size of holding in acres = Net area sown in acres plus current fallow in acres

In Uttar Pradesh and Madras, the data on size of farms as such was given and hence no adjustments were needed. For West Bengal, the details on land utilization were not available but only the tenurial status as area owned in acres, area leased-out in acres was given. Hence the size of holding was worked out as follows:

Size of holding = Owned land plus area leased-in minus area leased-out.

As mentioned earlier, the size of the holding was used as an institutional factor in the equations. Hence, outputs and inputs for each holding were worked out on per acre basis. For instance, the total value of physical output was divided by the size of holding in acres in case of 'farm business as a whole' and by area under the crop in case of a crop enterprise.

TABLE 4

COST AND HIRE CHARGES OF BULLOCK LABOUR PER DAY

Enterprise	Rate per day (in Rs.)	Remarks
Farm Business, Nasik District, Bombay	0.56 (1.00)	Cost per bullock for a day
Farm Business, Ahmednagar District, Bombay	1.13 (1.00)	"
Jowar, unirrigated, Ahmednagar District, Bombay	0.56 (1.72)	"
Irrigated jowar, Ahmednagar District, Bombay	0.43 (1.03)	"
Wheat, unirrigated, Nasik District, Bombay	0.96 (1.77)	"
Wheat, irrigated, Nasik District, Bombay	0.64 (1.50)	"
Wheat, irrigated, Ahmednagar District, Bombay	0.48 (1.05)	"
Farm Business, Meerut and Muzaffarnagar Districts, Uttar Pradesh	4.60	Cost per pair of bullocks for a day.
Sugarcane (planted), Meerut and Muzaffarnagar Districts, Uttar Pradesh	5.18	"
Sugarcane (ratoon), Meerut and Muzaffarnagar Districts Uttar Pradesh	5.33	"
Wheat, irrigated, Meerut and Muzaffarnagar Districts, Uttar Pradesh	4.35	"
Farm Business, Hoogly District, West Bengal	1.73	Cost per bullock for a day
	....	continued

Enterprise	Rate per day (in Rs.)	Remarks
Farm Business, 24-Parganas District, West Bengal	1.86	Cost per bullock for a day
Aus-paddy, Hoogly District, West Bengal	1.43	"
Aus-paddy, 24-Parganas District, West Bengal	1.41	"
Jute, Hoogly District, West Bengal	1.46	"
Jute, 24-Parganas District, West Bengal	1.43	"
Farm Business, Coimbatore District, Madras	0.56	"
Farm Business, Salem District, Madras	1.07	"
Paddy (Season I), Coimbatore and Salem Districts, Madras	0.51	"
Paddy (Season II), Coimbatore District, Madras	0.76	"
Paddy (Season II), Salem District, Madras	0.41	"
Jowar, irrigated, Coimbatore District, Madras	1.09	"
Jowar, irrigated, Salem District, Madras	0.49	"
Cotton, irrigated, Coimbatore District, Madras	0.91	"
Cotton irrigated, Salem District, Madras	0.49	"

Note: Figures in parentheses denote hire charges for bullock labour.

CHAPTER VI

METHODOLOGY

Regression Analysis

Curvilinear regression analysis[1] was carried out to study the input-output relationships for different crop enterprises and 'farm business as a whole.'

Quadratic and Cobb-Douglas functions of the following forms were used in the regression analysis :

Quadratic Function[2]:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 - b_6X_1^2 - b_7X_2^2 - b_8X_3^2 \pm b_9X_1X_2 \pm b_{10}X_1X_3 \pm b_{11}X_2X_3$$

Cobb-Douglas Function :

$$Y = a\, X_1^{b_1}\, X_2^{b_2}\, X_3^{b_3}\, X_4^{b_4}\, X_5^{b_5}$$

where Y is the value of gross returns from crop production per acre.

X_1	=	the number of human labour days used per acre.
X_2	=	the number of bullock labour days used per acre.
X_3	=	the size of holding in acres.
X_4	=	the value of fertilizers and manures used per acre.
X_5	=	the percentage of irrigated area in the holding.
a	=	the constant
$b_1 .. b_{11}$	=	are the regression coefficients or elasticities of production of the respective variables.

1. The detailed regression analysis performed in the present study was restricted to one year data for each state. As pointed out in the introductory part, this study is complementary to what has already been accomplished. Generally the data for the year for which no comparable production equations were prepared in the studies of the Directorate of Economics and Statistics, were used for regression analysis.

2. Due to limitations in the Programming for the Quadratic Function only linear terms of X_4 and X_5 were retained while the square terms and cross products involving X_4 and X_5 were dropped.

In all, thirty input-output relationships were estimated covering important crops in each region and 'farm business as a whole' in each district. The input-output relationship and the variables included are given in Table 5.

The equations were fitted by the IBM 1620 Electronic Computors available at the Institute of Agricultural Research Statistics, New Delhi and at the Delhi School of Economics, Delhi. For each equation, a reference number (called equation number) was used. Two to three runs of the regression analysis with varying number of variables were done for each relationship to eliminate the non-significant variables from the equations. The equations obtained from the first run on the electronic computer are given in Appendices I and II. The corrected sum of squares, the regression sum of squares, the percentage variation due to regression and the multiple coefficient of determination for these equations are also given. The standard errors of coefficients are given in parenthesis just below the coefficients.

The following steps were used to eliminate the statistically non-significant and undesirable variables from the equations.

(1) The standard errors of the regression coefficients were examined and only those variables whose coefficients were greater than their standard errors were selected for the second run.

(2) The simple correlation coefficients between returns and each input and also between the inputs themselves were examined. Those variables whose simple correlation coefficients with returns

TABLE 5

RELATIONSHIPS STUDIED

Sl. No.	Relationship	Variables included	Equation Number
1	Farm Business, Nasik (District) Bombay	X_1, X_2, X_3, X_4	1
2	Farm Business, Ahmednagar (District) Bombay	X_1, X_2, X_3, X_5	2
3	Jowar-unirrigated, Ahmednagar (District) Bombay	X_1, X_2, X_3	3
4	Jowar-irrigated, Ahmednagar (District) Bombay	X_1, X_2, X_3	4
5	Wheat-unirrigated, Nasik (District) Bombay	X_1, X_2, X_3	5
6	Wheat-irrigated, Nasik (District) Bombay	X_1, X_2, X_3	6
7	Wheat-irrigated, Ahmed nagar (District) Bombay	X_1, X_2, X_3	7
8	Farm Business, Meerut (District) Uttar Pradesh	X_1, X_2, X_3, X_4, X_5	8
9	Farm Business, Muzaffarnagar (District), Uttar Pradesh	X_1, X_2, X_3, X_4, X_5	9
10	Sugarcane-planted, Meerut (District) Uttar Pradesh	X_1, X_2, X_3, X_4	10
11	Sugarcane-planted, Muzaffarnagar (District), Uttar Pradesh	X_1, X_2, X_3, X_4	11
12	Sugarcane-ratoon, Meerut (District) Uttar Pradesh)	X_1, X_2, X_3, Y_4	12
13	Sugarcane-ratoon, Muzaffarnagar (District), Uttar Pradesh	X_1, X_2, X_3, X_4	13
14	Wheat-irrigated, Muzaffarnagar (District), Uttar Pradesh	X_1, X_2, X_3	14
15	Farm Business, Hoogly (District) West Bengal	X_1, X_2, X_3, X_4	15

..... continued

Sl. No.	Relationship	Variables included	Equation Number
16	Farm Business, 24 Parganas (District) West Bengal	X_1, X_2, X_3, X_4	16
17	Aman-paddy, Hoogly (District) West Bengal	X_1, X_2, X_3	17
18	Aus-paddy, Hoogly (District) West Bengal	X_1, X_2, X_3, X_4	18
19	Aus-paddy, 24 Parganas (District) West Bengal	X_1, X_2, X_3, X_4	19
20	Jute Hoogly (District) West Bengal	X_1, X_2, X_3, X_4	20
21	Jute, 24 Parganas (District) West Bengal	X_1, X_2, X_3, X_4	21
22	Farm Business, Coimbatore (District) Madras	X_1, X_2, X_3, X_4, X_5	22
23	Farm Business, Salem (District) Madras	X_1, X_2, X_3, X_4	23
24	Paddy-irrigated, (Season I) Salem and Coimbatore (Districts) Madras	X_1, X_2, X_3, X_4	24
25	Paddy-irrigated (Season II) Coimbatore (District), Madras	X_1, X_2, X_3, X_4	25
26	Paddy-irrigated (Season II) Salem (District) Madras	X_1, X_2, X_3, X_4	26
27	Jowar-irrigated, Coimbatore (District) Madras	X_1, X_2, X_3	27
28	Jowar-irrigated, (Season II) Salem (District) Madras	X_1, X_2, X_3, X_4	28
29	Cotton-irrigated, Coimbatore (District), Madras	X_1, X_2, X_3	29
30	Cotton-irrigated, Salem (District) Madras	X_1, X_2, X_3	30

X_1 = Human labour days per acre
X_2 = Bullock labour days per acre
X_3 = Size of holding in acres
X_4 = Value of fertilizers and manures used per acre
X_5 = Percentage of area irrigated

were significant at 5 per cent level were retained for the second run even though the 't' values of their regression coefficients were not high.

(3) Variables having negative regression coefficients, (linear terms in case of quadratic equations) due to the erratic nature of the data were also eliminated.

(4) Intercorrelation between inputs particularly between bullock labour and human labour was also examined and where the simple correlation coefficient was high (greater than 0.70), only one of these two variables (the variable which had higher 't' value for its regression coefficient) was retained while the other was eliminated.

After using these methods, it was found that some of the equations had to be rejected totally. Out of the 30 equations for each type of functions, 9 equations of the Cobb-Douglas type and 12 equations of the Quadratic type were dropped for the second run. The equation numbers were kept unchanged. Equations obtained in the second run are given in Appendices III and IV. All these equations were used for determining the marginal value productivities of labour at the geometric mean levels of inputs, and the values of marginal productivities are given in Tables 9 and 11.

For further economic analysis such as determination of the effects of other inputs on the productivity of labour and estimation of economic optimum levels, these equations were further scrutinised for a final run in which only those variables and those equations

were retained whose coefficients were significant at 5 per cent level. With this process of elimination only 20 equations in Cobb-Douglas type and 3 in Quadratic type of functions were retained. These equations are given in Chapter VII discussing the "Effect of Other Factors on the Marginal Value Products of Human Labour and Bullock Labour."

After persuing the results of the third run 12 equations of the Cobb-Douglas and 3 of the Quadratic type were retained for the estimation of economic optimum levels.

Estimation of Marginal Value Products

The marginal value products of human labour and bullock labour were estimated by taking partial derivatives of returns with respect to the inputs concerned calculated at the geometric mean levels of the inputs. The steps involved are described below:

Cobb-Douglas Type of Functions :

$$Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3}$$

where[3] Y = the return in rupees per acre.

X_1, X_2, X_3 are the independent variables or inputs.

The partial derivatives of returns (Y) with respect to the input X_1

$$\frac{dY}{dX_1} = a b_1 X_1^{b_1 - 1} X_2^{b_2} X_3^{b_3}$$

The marginal value product of X_1 ($MVPX_1$) was then obtained by substituting the corresponding geometric mean values of X_1, X_2, X_3 in the above equation.

3. The same symbols will be followed throughout this Chapter unless otherwise specified.

Quadratic Type of Functions :

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 - b_4 X_1^2 - b_5 X_2^2 - b_6 X_3^2 \pm b_7 X_1 X_2 \pm b_8 X_1 X_3 \pm b_9 X_2 X_3$$

The partial derivative of returns with respect to the input X_1 is given below:

$$\frac{dY}{dX_1} = b_1 - 2 b_4 X_1 \pm b_7 X_2 \pm b_8 X_3$$

The marginal value product of X_1 ($MVPX_1$) was then obtained by substituting the corresponding geometric or arithmetic means of X_1, X_2 and X_3 in the equation.

Estimation of Economic Optimum Levels of Human Labour and Bullock Labour

The economic optimum levels of human or bullock labour were obtained as follows:

From the given production equation, the partial derivatives of Y (returns in rupees) were worked out with respect to X_1 (human labour days) and X_2 (bullock labour days) holding the values of X_3 and X_5 at their geometric means. These partial derivatives were then equated with the corresponding prices of human labour day and bullock labour day. The values of X_1 and X_2 (of the partial derivative equations) were then solved simultaneously. The values so obtained were the economic optimum levels of human labour days and bullock labour days, with other inputs at their geometric or arithmetic means.

The steps involved are described below:

Cobb Douglas Function :

$$Y = a X_1^{b_1} X_2^{b_2}$$

The partial derivatives are :

$$\frac{dY}{dX_1.X_2} = a\, b_1\, X_1^{b_1 - 1}\, X_2^{b_2}$$

$$\frac{dY}{dX_2.X_1} = a\, b_2\, X_1^{b_2 - 1}\, X_1^{b_1}$$

Setting these partial derivatives against their respective prices i.e. Px_1 and Px_2, we get

$$a\, b_1\, X_1^{b_1 - 1}\, X_2^{b_2} = Px_1$$

$$a\, b_2\, X_2^{b_2 - 1}\, X_1^{b_1 -} = Px_2$$

These two equations were solved simultaneously to obtain the unknown values of X_1 and X_2 which are the economic optimum input levels of X_1 and X_2 respectively. For solving the equations were converted into the logarithmic form as follows:

$$\log a + \log b_1 \pm (b_1 - 1) \log X_1 + b_2 \log X_2 = \log Px_1$$

$$\log a + \log b_2 \pm (b_2 - 1) \log X_2 + b_1 \log X_1 = \log Px_2$$

The values of X_1 and X_2 were obtained in logarithmic form. By taking the antilogarithmic values the economic optimum levels were obtained.

Quadratic Type of Functions :

$$Y = a + b_1 X_1 + b_2 X_2 - b_3 X_1^2 - b_4 X_2^2 \pm b_5 X_1 X_2$$

Taking the partial derivatives of Y with respect to X_1 and X_2 and then equating them with the respective prices of X_1 and X_2 we get:

$$\frac{dY}{dX_1} = b_1 - 2\,b_3\,X_1 \pm b_5\,X_2 = Px_1$$

$$\frac{dY}{dX_2} = b_2 - 2\,b_4\,X_2 \pm b_5\,X_1 = Px_2$$

By solving these two equations simultaneously for the unknown values of X_1 and X_2 the economic levels were obtained.

CHAPTER VII

FINDINGS AND DISCUSSION

The findings of this study are reported under five major heading viz. Correlation Analysis, Production Function Analysis, Marginal value products, Effect of Other Factors on the Marginal Value Products of Human Labour and Bullock Labour and the Estimation of Economic Optimum Levels of Use of Human Labour and Bullock Labour.

Correlation Analysis

In the discussion of the results of Correlation Analysis at first Correlation between dependent variables and independent variables and secondly intercorrelation between independent variables are given.

The Simple correlation coefficients between the dependent variable (output) and the independent variables (inputs) and the intercorrelation between inputs used in the equations have been worked out. These are shown in Table 6.

Correlation Between Returns and Independent Variables

Returns and Human Labour :

The correlation between returns and human labour days per acre was found to be positive in almost all the relationships except for the 'farm business as a whole' in both the districts of West Bengal, where the coefficient was found to be negative though it was not statistically significant in Hoogly district,

West Bengal. When 'farm business as a whole' was considered, the correlation coefficients between yield and human labour days were high[1] in Bombay, low in Madras and Utter Pradesh and the lowest in West Bengal. Among individual crop enterprises, high correlation coefficients were found in unirrigated jowar and wheat in Bombay, irrigated paddy (Season II) in Coimbatore and irrigated cotton in Madras.

Returns and Bullock Labour :

Positive correlation was found to exist between yield and bullock labour input in the majority of the situations. In sugarcane (ratoon) crop of Uttar Pradesh and farm business of Hoogly district, the relationship was negative though the coefficients were not significant even at 10 per cent level. The positive correlation was not statistically significant in cases of farm business and aus-paddy in 24-Parganas district, Jute in both the districts of West Bengal and irrigated jowar in Coimbatore. The correlation coefficients were found to be high in farm business of both the districts of Bombay, low in Madras, Uttra Pradesh and lowest in West Bengal. Among individual crop enterprises, correlation between returns and bullock labour were high in Madras and Bombay but low in Uttar Pradesh and West Bengal.

Returns and Size of Holding :

Except in the cases of farm business in the districts of Bombay, 24-Parganas, in West Bengal and Salem in Madras, the correlations between returns and the size of holding were not

1. Whenever the value of coefficient of correlation is greater than 0.70 it is considered as high.

TABLE 6 CORRELATION ANALYSIS - SIMPLE CORRELATION BETWEEN THE VARIABLES

Sl. No.	Description	n	$r_{X_1X_2}$	$s_{X_1X_2}$	$r_{X_1X_3}$	$s_{X_1Y_3}$	$r_{X_2X_3}$	$s_{X_2X_3}$	r_{YX_1}	s_{YX_1}	r_{YX_2}	s_{YX_2}	r_{YX_3}	s_{YX_3}	r_{YX_4}	s_{YX_4}	r_{YX_5}	s_{YX_5}
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.	Farm Business, Nasik (District) Bombay	61	0.8776	0.0299	-0.0993^{+}	0.1302	-0.3300	0.1229	0.9110	0.0537	0.7725	0.0827	-0.2560	0.1257	0.6564	0.0982	-	-
2.	Farm Business, Ahmed nagar (District) Bombay	77	0.8598	0.0301	-0.3882	0.1053	-0.3941	0.1061	0.8016	0.0690	0.7512	0.0751	-0.2675	0.1113	-	-	0.5316	0.0978
3.	Jowar-unirrigated, Ahmed nagar (District) Bombay	55	0.8061	0.0481	-0.2401**	0.1320	-0.2243**	0.1339	0.8111	0.0803	0.6008	0.1098	-0.1087	0.1365	-	-	-	-
4.	Jowar-irrigated, Ahmed nagar (District) Bombay	50	0.7847	0.0555	-0.2947	0.1379	-0.3252	0.1365	0.6314	0.1119	0.3913	0.1314	0.1322^{+}	0.1416	-	-	-	-
5.	Wheat-unirrigated, Nasik (District) Bombay	31	0.9461	0.0195	-0.0368**	0.1856	-0.0077^{+}	0.1857	0.7587	0.1191	0.8984	0.0816	0.0051^{+}	0.1857	-	-	-	-
6.	Wheat-irrigated, Nasik (District) Bombay	32	0.8600	0.0475	-0.3917**	0.1728	-0.2671**	0.1759	0.3869	0.1723	0.6904	0.1474	-0.1825^{+}	0.1795	-	-	-	-
7.	Wheat-irrigated, Ahmed nagar (District) Bombay	36	0.8436	0.0502	-0.3971	0.1598	-0.3133**	0.1653	0.2934**	0.1664	0.2695^{+}	0.1681	0.0021^{+}	0.1741	-	-	-	-
8.	Farm Business, Meerut (District) U.P.	100	0.4457	0.0810	-0.2863	0.0968	-0.0744^{+}	0.1007	0.5468	0.0845	0.4131	0.0910	-0.0822^{+}	0.0566	0.5033	0.0873	0.0259^{+}	0.1020
9.	Farm Business, Muzaffar nagar (District) U.P.	96	0.7139	0.0506	-0.3344	0.0972	-0.2309	0.1004	0.2329	0.1003	0.2187**	0.1006	-0.0084^{+}	0.1031	0.1560^{+}	0.1019	0.2254	0.0991
10.	Sugarcane-planted, Meerut (District) U.P.	87	0.3938	0.0916	-0.1555^{+}	0.1071	0.1601^{+}	0.1072	0.6403	0.0833	0.1844**	0.1066	-0.1291^{+}	0.1065	0.4178	0.0985	-	-
11.	Sugarcane-planted, Muzaffar nagar (District) U.P.	78	0.3413	0.1013	-0.0887^{+}	0.1117	-0.1602^{+}	0.1132	0.4260	0.1038	0.4391	0.1031	-0.0467^{+}	0.1146	0.3273	0.1079	-	-
12.	Sugarcane-ratoon, Meerut (District) U.P.	91	0.1504^{+}	0.1036	-0.3020	0.1011	-0.0150^{+}	0.1060	0.2392	0.1019	-0.0093^{+}	0.1060	-0.1501^{+}	0.1048	0.1670^{+}	0.1045	-	-
13.	Sugarcane-ratoon, Muzaffar nagar (District) U.P.	86	0.5363	0.0782	-0.1865^{+}	0.1078	-0.1651^{+}	0.1084	0.6928	0.0884	0.3970	0.1007	-0.1531^{+}	0.1085	0.1501^{+}	0.1085	-	-
14.	Wheat-irrigated, Muzaffar nagar (District) U.P.	53	0.6457	0.0816	-0.2788	0.1078	-0.1951^{+}	0.1359	0.3033	0.1334	0.3202	0.1327	-0.0191^{+}	0.1400	-	-	-	-

..... continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
15.	Farm Business, Hoogly (District) West Bengal	75	0.2971	0.1067	-0.1402^{+}	0.1147	-0.0261^{+}	0.1170	-0.0579^{+}	0.1168	-0.0260^{+}	0.1170	-0.0278^{+}	0.1170	-0.0429^{+}	0.1169	-	-
16.	Farm Business, 24 Parganas (District) W.Bengal	98	0.8834	0.0224	-0.2714	0.0982	-0.1989	0.0990	-0.2202	0.0996	0.0973^{+}	0.1016	-0.4150	0.0929	0.2401	0.0806	-	-
17.	Aman-paddy, Hoogly (District), West Bengal	69	0.4194	0.1007	-0.0339^{+}	0.1221	-0.0692^{+}	0.1219	0.3790	0.1131	0.1925**	0.1186	-0.0068^{+}	0.1222	-	-	-	-
18.	Aus-paddy, Hoogly (District), West Bengal	18	0.4933	0.1892	-0.0694^{+}	0.2496	-0.0076^{+}	0.2500	0.1185^{+}	0.2482	0.5635	0.2095	-0.1036^{+}	0.2487	0.9721	0.0876	-	-
19.	Aus-paddy, 24 Parganas (District), W.Bengal	19	0.6829	0.1360	-0.2575^{+}	0.2343	-0.3376^{+}	0.2283	0.4013**	0.2221	0.1917^{+}	0.2366	-0.0024^{+}	0.2425	-0.0001^{+}	0.2425	-	-
20.	Jute, Hoogly (District) West Bengal	46	0.5703	0.1100	-0.1954^{+}	0.1463	0.0511^{+}	0.1606	0.3846	0.1392	0.0346^{+}	0.1507	0.0051^{+}	0.1508	-0.0545^{+}	0.1506	-	-
21.	Jute, 24 Parganas (District) W. Bengal	40	0.4716	0.1262	-0.1024^{+}	0.1614	0.0770^{+}	0.1617	0.4888	0.1416	0.0287^{+}	0.1622	-0.0011^{+}	0.1622	-0.1012^{+}	0.1614	-	-
22.	Farm Business, Coimbatore (District) Madras	97	0.6962	0.0529	-0.2301	0.0998	0.0785^{+}	0.1023	0.7005	0.0732	0.4844	0.0898	-0.1601^{+}	0.1013	0.5918	0.0827	0.5014	0.0888
23.	Farm Business, Salem (District) Madras	94	0.8107	0.0350	-0.2835	0.0989	-0.1364^{+*}	0.1011	0.3585	0.0963	0.3018	0.0983	-0.1865**	0.1012	0.4004	0.0945	-	-
24.	Paddy-irrigated (Season I) Salem & Coimbatore (District) Madras	47	0.7028	0.0800	-0.2472**	0.1632	-0.3079**	0.1604	0.6112	0.1251	0.5473	0.1323	-0.1590^{+}	0.1561	0.7783	0.0981	-	-
25.	Paddy-irrigated (Season II) Coimbatore (District) Madras	21	0.8730	0.0546	-0.2936^{+}	0.2193	-0.2829^{+}	0.2236	0.8580	0.1166	0.5344	0.0516	-0.2791^{+}	0.2180	0.9094	0.0954	-	-
26.	Paddy-irrigated (SeasonII) Salem (District) Madras	28	0.3031	0.1781	-0.2228^{+}	0.1913	-0.2967^{+}	0.1873	0.7187	0.1364	0.7646	0.1264	-0.2004^{+}	0.1921	0.4726	0.1728	-	-
27.	Jowar-irrigated (SeasonIII) Coimbatore (District) Madras	29	0.9187	0.0760	-0.0640	0.0041	0.0136^{+}	0.1907	0.3122**	0.1828	0.0538^{+}	0.1922	-0.0775^{+}	0.1919	-	-	-	-
28.	Jowar-irrigated (SeasonIII) Salem (District) Madras	28	0.9806	0.0075	-0.3990	0.1798	-0 4027	0.1795	0.9164	0.0785	0.9236	0.0782	-0.2569^{+}	0.1890	-0 1696^{+}	0.1933	-	-
29.	Cotton-irrigated(SeasonIII) Coimbatore (District) Madras	36	0.9863	0.0050	-0.1986^{+}	0.1664	-0.1783^{+}	0.1688	0.9787	0.0344	0.9700	0.1518	-0.1923^{+}	0.1666	-	-	-	-
30.	Cotton-irrigated(SeasonIII) Salem (District) Madras	21	0.5162	0.1683	-0.1871^{+}	0.2254	-0.1758^{+}	0.2258	0.3384^{+}	0.2159	0.8001	0.1878	-0.3984**	0.2104	-	-	-	-

SYMBOLS USED IN TABLE 6

Y	=	Value of output in Rupees per acre.
X_1	=	The number of human labour days used per acre.
X_2	=	Number of bullock labour days used per acre.
X_3	=	Size of holding in acres.
X_4	=	The values of fertilizers and manures used per acre.
X_5	=	Percentage of area irrigated in the holding.
rX_1X_2	=	Correlation coefficient between human labour and bullock labour.
rX_1X_3	=	Correlation coefficient between human labour and size of holding.
rX_2X_3	=	Correlation coefficient between bullock labour and size of holding.
rYX_1	=	Correlation coefficient between output and human labour.
rYX_2	=	Correlation coefficient between output and bullock labour.
rYX_3	=	Correlation coefficient between output and size of holding.
rYX_4	=	Correlation coefficient between output and fertilizers and manures used.
rYX_5	=	Correlation coefficient between output and the percentage of area irrigated.

$S_{X_1X_2}$	=	Standard Error of rX_1X_2
$S_{X_1X_3}$	=	Standard Error of rX_1X_3
$S_{X_2X_3}$	=	Standard Error of rX_2X_3
S_{YX_1}	=	Standard Error of rYX_1
S_{YX_2}	=	Standard Error of rYX_2
S_{YX_3}	=	Standard Error of rYX_3
S_{YX_4}	=	Standard Error of rYX_4
S_{YX_5}	=	Standard Error of rYX_5

Correlation coefficients are significant at 5 per cent level.

** Correlation are significant at 10 per cent level.

+ Correlation coefficients are not significant even at 10 per cent level.

statistically significant. In all the above cases the correlation was found to be negative. In Uttar Pradesh and Madras also, these correlation coefficients were negative, however, statistically not significant. The same situation existed in West Bengal except in case of jute crop in Hoogly district. In Bombay the relationship was positive but not statistically significant, with irrigated jowar and wheat of Ahmednagar district and unirrigated wheat of Nasik district.

Returns and Fertilizers and Manures :

Crop yields were positively correlated with the amounts of fertilizers and manures applied. In a few cases the coefficients were statistically not significant but in no case was the coefficient negative. High correlation values were found in case of irrigated paddy (Season I) in Madras, in irrigated paddy (Season II) of Coimbatore district, Madras, aus-paddy of Hoogly district, West Bengal and 'farm business as a whole' in Nasik district, Bombay.

Returns and the Percentage Area Irrigated :

In all the four cases studied the returns were found to be positively correlated with the percentage of area under irrigation. In Bombay and Madras where well irrigation is more prevalent, the values of correlation coefficients were high. In Meerut, the value was not statistically significant while in Muzaffarnagar it was significant but low. It may be noted that in these two districts, a sizeable area is under canal irrigation.

Intercorrelation between Independent Variables

Human labour and Bullock Labour:

Per acre inputs of human labour and bullock labour were found to be positively correlated in all the cases (except in ratoon sugarcane in Meerut district and irrigated paddy, Season II, in Salem district of Madras. In the former case, the ratoon crop needs very few bullock labour days). High correlation between these two variables was found in Bombay in almost all the crop enterprises. In five farm enterprises out of nine in Madras, the correlation coefficients were high. In the irrigated crops of cotton and paddy (Season III), the correlation coefficients were as high as 0.98. The correlation was low in West Bengal and Uttar Pradesh.

Human Labour and Size of Holding :

The human labour input per acre and the size of holding were found to be negatively correlated. In many cases the coefficients were not statistically significant. Generally the correlation was low.

Bullock Labour and Size of Holding :

In most of the cases the relationship between bullock labour used per acre and the size of holding was not statistically significant. Wherever the relationships were significant, these two variables were negatively correlated. In Bombay the correlation coefficients were found to be significant at five per cent level except in irrigated wheat of Ahmednagar where it was significant at 10 per cent level only. For 'farm business as a whole' in Muzaffarnagar and in 24-Parganas districts, the relationship was

negatively correlated and the correlation coefficients were significant at five per cent level.

Production Function Analysis

After eliminating the variables according to the criteria as discussed on page 40 in the Methodology Chapter, the equations developed in the second run were used for production function analysis. The equations developed in the second run are given in Appendices III and IV.

Regression Coefficients for Cobb-Douglas Type of Functions-Elasticities of Production :

In Cobb-Douglas Type functions the regression coefficients are equivalent to the elasticities of production for the inputs, hence they are discussed under this term. Table 8 shows the production elasticities of human labour and bullock labour.

The production elasticity of human labour for all cases included in the study was positive. Considerable variation was noticed in the production elasticity of human labour between regions and between crops within the regions. The production elasticity ranged from 0.13453 to 1.25787. It appears that wherever rainfall was high and irrigation was assured the production elasticity of human labour was found to be low as in West Bengal and Uttar Pradesh. Elasticity of production for human labour was generally higher in Madras and Bombay than in Uttar Pradesh and West Bengal.

When 'farm business as a whole' was considered the highest value of elasticity of production of human labour was

TABLE 7-8

PRODUCTION ELASTICITIES OF HUMAN LABOUR AND BULLOCK LABOUR

Equation No.	Enterprise	Production elasticity of Human Labour	Production elasticity of Bullock Labour	Variables used in the Function	R^2 or r^2
1	Farm Business, Nasik district, Bombay	0.31511	0.68272	X_1, X_3	0.77515
2	Farm Business, Ahmednagar district, Bombay	0.69593	-	X_1, X_5	0.50942
3	Jowar unirrigated, Ahmednagar district, Bombay	1.09984	-	X_1, X_3	0.58581
5	Wheat unirrigated, Nasik district, Bombay	0.80442	-	X_1	0.46946
6	Wheat irrigated, Nasik district, Bombay	1.25787	-0.58918	X_1, X_2	0.48690
7	Wheat irrigated, Ahmednagar district, Bombay	-	0.39106	X_2, X_3	0.23022
8	Farm Business, Meerut district, Uttar Pradesh	0.30503	0.39151	X_1, X_2, X_4	0.39816
11	Sugarcane (planted), Muzaffarnagar, district, Uttar Pradesh	0.31550	0.40755	$X_1, X_2,$	0.24660
16	Farm Business, 24-Parganas district, West Bengal	0.13453	-	X_1, X_3	0.78194
17	Aman-paddy, Hoogly district, West Bengal	0.36751	-	$X_1,$	0.19400
20	Jute, Hoogly district, West Bengal	0.37942	0.21727	X_1, X_2	0.23260

..... continued

Equation No.	Enterprise	Production elasticity of Human Labour	Production elasticity of Bullock Labour	Variables used in the Function	R^2 or r^2
21	Jute, 24-Parganas district, West Bengal	0.41148	-0.02457	X_1, X_2	0.29465
22	Farm Business, Coimbatore district, Madras	0.66187	0.19148	X_1, X_2	0.55000
23	Farm Business, Salem district, Madras	0.98221	0.03376	X_1, X_3	0.39757
24	Paddy-irrigated, (Season I), Madras	0.66837	-	X_1	0.49300
25	Paddy-irrigated, (Season II), Coimbatore, district, Madras	0.59241	-	X_1	0.72548
26	Paddy-irrigated, (Season II), Salem district, Madras	0.61133	-	X_1, X_3	0.53159
28	Jowar-irrigated, (Season II), Salem district, Madras	0.83168	-	X_1	0.57111
29	Cotton-irrigated, Coimbatore district, Madras.	0.44883	0.39233	X_1, X_2	0.79258
30	Cotton-irrigated, Salem district, Madras	1.13340	-	X_1, X_3	0.64627

X_1 = the number of human labour days used per acre.
X_2 = the number of bullock labour days used per acre.
X_3 = size of holding in acres.
X_4 = the value of fertilizers and manures used per acre.

r^2 = the coefficient of determination.
R^2 = the coefficient of multiple determination

found in Salem district, Madras (0.98221), and the lowest value in 24-Parganas district, West Bengal (0.13453).

Among individual crop enterprises irrigated wheat in Nasik district, Bombay was found to have the largest production elasticity of human labour (1.25787) and sugarcane (planted) Muzaffarnagar, Uttar Pradesh, the smallest (0.31550). With regard to variations in the elasticity of production of human labour between crops in a region, results in both Ahmednagar and Nasik district, Bombay have shown higher values in irrigated wheat than unirrigated wheat and jowar. In the Hoogly district, West Bengal, the production elasticity of human labour for the jute crop was slightly higher than the aman paddy 0.37943 and 0.36751 respectively. In Salem district, Madras the production elasticity of human labour for cotton was larger than for irrigated paddy (Season II) or irrigated jowar while in Coimbatore district, Madras, the production elasticity of human labour for irrigated cotton was lower than for irrigated paddy.

The production elasticity of bullock labour was found to be positive in all cases studied except in irrigated wheat of Nasik district, Bombay and in jute of 24-Parganas district, West Bengal. As in human labour considerable variation was noticed in the production elasticity of bullock labour between regions and between enterprises within the regions. The values of production elasticity of bullock labour were found to range from - 0.58918 to 0.68272.

When 'farm business as a whole' was considered the smallest value of production elasticity of bullock labour was found in Coimbatore district, Madras and the highest value in Nasik district, Bombay (0.19148 and 0.68272 respectively).

Among individual crop, production elasticity of Bullock labour was smallest in irrigated wheat Nasik district, Bombay (-0.58918) and largest in sugarcane (planted), Meerut district, Uttar Pradesh (0.40755).

Regression Coefficients for Quadratic Type Equations:

Regression coefficients of human labour in the equation dealing with 'farm business as a whole were 0.49963 in Salem district of Madras and 4.44912 in unirrigated wheat in Nasik district of Bombay. Only in these two cases were the coefficients in the Quadratic Type of Functions statistically significant at 5 per cent level. Thus, because of the small number of significant coefficients a meaningful comparison between regions and between crops within the regions could not be made.

Regression coefficients of bullock labour in aus-paddy in 24-Parganas district, West Bengal, was found to be 2.73224. Again in the absence of any other statistically significant coefficients, no inter-regional or intercrop comparison were possible to make.

Marginal Value Products

The estimated values of the marginal value products for human labour and for bullock labour are given in Tables 9 to 12. As an illustration, the steps involved in the determination of marginal value products are given below:

Equation Number 3 : Jowar-unirrigated, Ahmednagar district, Bombay (Quadratic Type)

$$Y = 2.17976 + 1.56470\ X_1 - 0.37965\ X_3 - 0.00105\ X_1^2 + 0.00314\ X_3^2 + 0.02339\ X_1 X_3$$

Marginal value products of human labour

$$MVP\ X_1 = \frac{dY}{dX_1} = 1.56470 - 0.00210\ X_1 + 0.02339\ X_1 X_3$$

Substituting the arithmetic means of X_1 and X_3 in the above equation we get:

$$MVP\ X_1 = 1.56470 - 0.00210\ (15.00945) + 0.02339\ (25.44800)$$

$$= 2.12841 = Rs.\ 2.13$$

Equation Number 3 : Jowar-unirrigated, Ahmednagar district, Bombay (Cobb-Douglas Type)

$$Y = 0.88984\ X_1^{1.09957}\ X_3^{0.09659}$$

Marginal value product of human labour

$$MVP\ X_1 = \frac{dY}{dX_1} = 0.88948\ (1.09957)\ X_1^{0.09957}\ X_3^{0.09659}$$

$$\log MVP\ X_1 = \log 0.88980 + \log 1.09960 + 0.09960\ (1.08965) + 0.09660\ (1.26720)$$

$$= \bar{1}.94929 + 0.04123 + 0.09960\ (1.08965) + 0.09660\ (1.26720)$$

$$= 0.22146$$

$$MVP\ X_1 = \text{Anti log } 0.22146 = 1.665$$

Hence Marginal Value Product of Human Labour = Rs. 1.67

In Tables 9 and 11 in addition to the marginal value products, the input levels at geometric mean, the wage rate of human labour, costs per day of bullock labour and the coefficient of determination are also given. Table 10 and 12 show the marginal value products of human labour and bullock labour estimated under the present study and those worked out by other authors.

Marginal value product of human labour :

Except in case of 'farm business as a whole' in Meerut district, Uttar Pradesh and individual crop enterprises in the districts of Hoogly and 24-Parganas in West Bengal, the marginal value products of human labour were higher than the prevailing wage rate for all enterprises as well as for 'farm business as a whole' in the States of Bombay, Madras, aUttar Pradesh and West Bengal.

When 'farm business as a whole was considered the Marginal Value Product of human labour was highest in the 24-Parganas district of West Bengal (Rs. 2.95) and the lowest in Ahmednagar district of Bombay (Rs. 1.18). Perhaps the low fertility level, arid climatic conditions, absence of irrigation, predominance of food crops in the cropping patter, partly explain the low marginal value product in Ahmednagar and Nasik districts. In farm business of Nasik district human labour input alone explained 76 per cent of the variation in return while in 24-Parganas district, West Bengal, the human labour input and size of holding together explained only 34 per cent of the variation in return.

TABLE 9 MARGINAL VALUE PRODUCTS OF HUMAN LABOUR IN RUPEES AT GEOMETRIC MEAN FOR VARIOUS ENTERPRISES

Equation No.	Enterprise	Geometric mean of human labour in days	Wage rate (Rs.)	Marginal value product at geometric mean	Size of holding (acres)	Variables included	Coefficient of determination
1	Farm Business, Nasik (District) Bombay	7.98	0.92	1.56	11.40	X_1	0.76
2	Farm Business, Ahmed nagar (District) Bombay	10.07	0.95	1.18 (10.91)**	14.97	X_1, X_5	0.51
3	Jowar-unirrigated, Ahmed nagar (District) Bombay	12.85	0.95	1.52 (2.13)@	18.50	X_1,	0.58
5	Wheat-unirrigated, Nasik (District) Bombay	18.17	0.92	1.52	12.57	X_1	0.47
6	Wheat-irrigated, Nasik (District) Bombay	85.29	0.92	1.92	15.18	X_1, X_2	0.49
8	Farm Business, Meerut (District), Uttar Pradesh	59.80	1.25	1.17	6.68	X_1, X_2, X_4	0.40
11	Sugarcane-planted, Muzaffar-nagar (District) Uttar Pradesh	71.34	1.25	1.87	11.27	X_1, X_2	0.25
13	Sugarcane-ratoon, Muzaffar nagar (District) Uttar Pradesh	53.47	1.25	(4.32)	10.56	X_1, X_3	0.47
14	Wheat-irrigated, Muzaffar nagar (District), Uttar Pradesh	33.31	1.25	2.34 (2.79)**	11.01	X_1, X_2, X_3	0.47

.... continued

Equation No.	Enterprise	Geometric mean of human labour in days
16	Farm Business, 24-Parganas (District) West Bengal	63.00
17	Aman-paddy, Hoogly (District), West Bengal	24.61
20	Jute, Hoogly (District) West Bengal	109.36
21	Jute, 24-Parganas (District), West Bengal	119.00
22	Farm Business, Coimbatore (District), Madras	27.64
23	Farm Business, Salem (District), Madras	49.89
24	Paddy-irrigated (Season I), Madras	122.40
25	Paddy-irrigated (Season II), Salem (District) Madras	171.84
26	Paddy-irrigated (Season II), Salem (District), Madras	97.95

Wage rate (Rs.)	Marginal value product at geometric mean	Size of holding (acres)	Variables included	Coefficient of determination
2.44	(2.95)	1.79	X_1, X_3	0.34
1.55	0.64	2.03	X_1	0.19
1.55	1.28	1.71	X_1, X_3	0.21
2.44	0.88	1.24	X_1, X_2	0.29
0.97	1.40	7.33	0. X_1, X_2	0.54
0.96	1.66 (2.46)	3.74	X_1, X_3	0.23
0.97	1.65	4.78	X_1	0.49
0.97	1.24	10.56	X_1	0.73
0.96	1.30	5.07	X_1, X_3	0.49

..... continued

Equation No.	Enterprise	Geometric mean of human labour in days	Wage rate (Rs.)	Marginal value product at geo-metric mean	Size of holding (acres)	Variables included	Coeffi-cient of det-ermi-nation
28	Jowar-irrigated (Season III), Salem (District), Madras	53.30	0.96	1.72	4.82	X_1	0.57
29	Cotton-irrigated (Season II), Coimbatore (District) Madras	52.56	0.97	1.10	9.61	X_1, X_2	0.97
30	Cotton-irrigated (Season II), Salem District, Madras	84.12	0.96	3.34	4.19	X_1, X_3	0.64

Note: The regression coefficients are significant at 5 per cent level

** Regression coefficients of human labour are significant at 10 per cent level

@ t-value (Regression coefficients/Standard error of the regression coefficients) is greater than unity.

Figures in parenthesis are the marginal value products estimated from Quadratic Type of Functions while all others are estimated from Cobb-Douglas Type of Functions.

TABLE 10 MARGINAL VALUE PRODUCTS OF HUMAN LABOUR IN RUPEES AT GEOMETRIC MEAN LEVEL IN DIFFERENT REGIONS FOR SELECTED ENTERPRISES

Enterprise	Year	Type of Function	Bombay		Uttar Pradesh			West Bengal		Madras			Punjab
			Nasik	Ahmed nagar	Meerut	Muzaffar-nagar	Com-bined	Hoogly	24-Parganas	Coim-batore	Salem	Com-bined	
Farm Business	1954-55	Quadratic	NS	0.91**	-	-	-	NS	2.86	NS	2.46	-	-
		Cobb-Douglas	1.56	1.18	-	-	2.42	NS	NS	1.40	1.66	-	1.88
	1955-56	Cobb-Douglas	-	-	-	-	0.52	-	-	-	-	-	1.78
	1956-57	Cobb-Douglas	-	-	1.17	NS	-	-	-	-	-	-	4.27
Wheat unirrigated	1954-55	Quadratic	0.77	-	-	-	-	-	-	-	-	-	-
		Cobb-Douglas	1.58	-	-	-	-	-	-	-	-	-	-
Wheat irrigated	1954-55	Quadratic	NS	NS	-	2.79**	-	-	-	-	-	-	-
		Cobb-Douglas	1.97	NS	-	2.34	-	-	-	-	-	-	-
Paddy-irrigated (Season I)	1954-55	Quadratic	-	-	-	-	-	NS	NS	-	-	NS	-
		Cobb-Douglas	-	-	-	-	-	NS	NS	-	-	1.65	-
Paddy-irrigated (Season II)	1954-55	Cobb-Douglas	-	-	-	-	-	0.64	-	1.84	1.30	0.63	-
	1955-56	Cobb-Douglas	-	-	-	-	-	-	-	-	-	NS	-
	1956-57	Cobb-Douglas	-	-	-	-	-	-	-	-	-	1.17	-
Jowar-unirrigated	1954-55	Quadratic	-	2.14	-	-	-	-	-	-	-	-	-
		Cobb-Douglas	-	1.62	-	-	-	-	-	-	-	-	-
Jowar irrigated	1954-55	Quadratic	-	-	-	-	-	-	-	10.52*	NS	-	-
		Cobb-Douglas	-	-	-	-	-	-	-	NS	1.72	1.71	-
	1955-56	Cobb-Douglas	-	-	-	-	-	-	-	-	-	2.28	-
	1956-57	Cobb-Douglas	-	-	-	-	-	-	-	-	-	1.00	-
Sugarcane-planted	1955-57	Cobb-Douglas	-	-	NS	1.87	-	-	-	-	-	-	-
Sugarcane-ratoon	1956-57	Quadratic	-	-	-	4.32	-	-	-	-	-	-	-
Jute	1954-55	Cobb-Douglas	-	-	-	-	-	1.98	0.88	-	-	-	-
Cotton	1954-55	Cobb-Douglas	-	-	-	-	-	-	-	1.10	3.34	1.88	-
	1955-56	Cobb-Douglas	-	-	-	-	-	-	-	-	-	0.87	-
	1956-57	Cobb-Douglas	-	-	-	-	-	-	-	-	-	1.27	-

Among individual crop enterprises sugarcane (ratoon) in Muzaffarnagar district showed the largest marginal value product for human labour (Rs. 4.32 at geometric mean level and Rs. 3.99 at arithmetic mean level). The irrigated cotton in Salem district of Madras State ranked second (Rs. 3.34). The lowest marginal value product of human labour was found in aman-paddy in Hoogly district of West Bengal (Rs. 0.64). Among food crops, irrigated wheat in Muzaffarnagar district showed the largest marginal value product of human labour (Rs. 2.34).

In Nasik district of Bombay, the marginal value product of human labour in irrigated wheat was higher than in unirrigated wheat even though the human labour input in the former was 4.7 times (85 days) than in the latter (18 days). In unirrigated wheat of Nasik district, human labour input alone explained 47 per cent of the variation in yield while in irrigated wheat human labour and bullock labour together explained only 49 per cent of the variation. The marginal value product of human labour in unirrigated jowar of Ahmednagar and unirrigated jowar in Nasik district were found to be the same at their respective geometric meanslevels of input. But in unirrigated jowar the human labour input used was only $\frac{2}{3}$ of that of irrigated jowar.

In Muzaffarnagar district, Uttar Pradesh, the marginal value product in ratoon sugarcane (Rs. 4.32) was nearly double that of in irrigated wheat (2.34). The geometric mean of the human labour input was larger by $\frac{1}{3}$rd in ratoon sugarcane than in irrigated wheat showing the much more labour intensive nature of the sugarcane ratoon crop.

The marginal value product of human labour was greater in jute than in aman-paddy in West Bengal. In Hoogly district, West Bengal, the marginal value product of human labour for jute was twice that of aman-paddy although the human labour input in jute was nearly 4½ times that in aman-paddy. At the same time the average size of holding was larger in aman-paddy sample than for the jute sample which fact gave rise to expectations of higher marginal value product for aman-paddy on these larger holdings.

In all enterprises, the marginal value product of human labour was higher in Salem district than in Coimbatore district of Madras State though the geometric mean level of human labour input in all the enterprises was higher in Salem district than in Coimbatore district. In Salem district, Madras irrigated cotton gave nearly double the marginal return for labour than in paddy or jowar at their respective geometric mean levels of human labour input. In Coimbatore, the marginal value product of human labour for irrigated cotton was smaller than in irrigated paddy, though in irrigated paddy the human labour input level was nearly three times that in irrigated cotton.

Marginal Value Product of Bullock Labour:

Except in irrigated-wheat in Muzaffarnagar district, Uttar Pradesh, in 'farm business as a whole' and jute in 24-Parganas district, West Bengal the marginal value products of bullock labour at the geometric means were higher than the prevailing costs per day of bullock labour. Of all the enterprises

TABLE 11

MARGINAL VALUE PRODUCTS OF BULLOCK LABOUR IN RUPEES AT GEOMETRIC MEAN FOR VARIOUS ENTERPRISES

Equation Number	Enterprise	Geometric Mean	Cost/day of Bullock Labour	Marginal Value product at Geometric Mean in Rs.	Size of holding in acres	R^2 or r^2	Variables included
1	Farm Business, Nasik (District), Bombay	9.13	0.56	1.38	11.40	0.77	X_2
6	Wheat-irrigated, Nasik (District), Bombay	65.91	0.54	1.97	15.18	0.47	X_1, X_2
7	Wheat-irrigated, Ahmednagar (District), Bombay	53.46	0.48	0.62	15.20	0.17	X_2
8	Farm Business, Meerut (District), Uttar Pradesh	17.98	4.60	4.95 (2.88)	6.88	0.40	X_1, X_2, X_4
11	Sugarcane(planted) Muzaffarnagar (District), Uttar Pradesh	15.69	5.18	12.69	11.27	0.25	X_1, X_2
14	Wheat-irrigated, Muzaffarnagar (District), Uttar Pradesh	21.15	4.35	3.40	11.01	0.47	X_1, X_2, X_3
16	Farm Business, 24-Parganas (District) West Bengal	17.25	1.86	1.60	1.79	0.78	X_2, X_3
19	Aus-paddy, 24-Parganas (District), West Bengal	18.00	1.41	(2.09)	2.17	0.45	X_2, X_3

..... continued

Equation Number	Enterprise	Geometric Mean	Cost/day of Bullock Labour	Marginal Value product at Geometric Mean in Rs.	Size of holding in acres	R^2 or r^2	Variables included
21	Jute, 24-Parganas (District), West Bengal	29.00	1.41	0.28	1.64	0.29	X_1, X_2
22	Farm Business, Coimbatore (District), Madras	15.76	0.56	0.71	7.33	0.54	X_1, X_2
29	Cotton (Season II), Coimbatore (District), Madras	27.92	0.91	1.09	9.01	0.79	X_1, X_2

Note: The regression coefficients are significant at 5 per cent level.

** Regression coefficients ofbullocklabour are significant at 10 per cent level

igures in parenthesis are the marginal value products estimated from Quadratic Type of Functions while all others are estimated from Cobb-Douglas Type of Functions.

TABLE 12 MARGINAL VALUE PRODUCTS OF BULLOCK LABOUR IN RUPEES AT GEOMETRIC MEAN LEVEL IN DIFFERENT REGIONS FOR SELECTED ENTERPRISES

Enterprise	Year	Type of Function	Bombay		Uttar Pradesh			West Bengal		Madras			Punjab
			Nasik	Ahmednagar	Meerut	Muzaffarnagar	Combined	Hoogly	24-Parganas	Coimbatore	Salem	Combined	
Farm Business	1954-55	Quadratic	NS	-	2.88	-	-	-	-	-	-	-	-
		Cobb-Douglas	1.38	-	4.95	-	1.13	-	1.60	0.71	-	-	-2.10
	1955-56	Cobb-Douglas	-	-	-	-	-	-	-	-	-		-2.00
	1956-57	Cobb-Douglas	-	-	-	-	-	-	-	-	-	-	0.95
Wheat-unirrigated	1954-55	Quadratic	1.61**	-	-	-	-	-	-	-	-	-	-
Wheat-irrigated	1954-55	Quadratic	1.24@	-	-	-	-	-	-	-	-	-	-
		Cobb-Douglas	1.94	0.62	-	-	-	-	-	-	-	-	-
	1956-57	Cobb-Douglas	-	-	-	3.40	-	-	-	-	-	-	-
Paddy-irrigated (Season I) and aus-paddy	1954-55	Quadratic	-	-	-	-	-	-	2.09	-	-	-	-
Paddy-irrigated (Season II)	1954-55	Cobb-Douglas	-	-	-	--	-	-	-	-	-	0.0088	-
Jowar-irrigated	1954-55	Cobb-Douglas	-	-	-	-	-	-	-	-	-	1.85	-
J	1955-56	Cobb-Douglas	-	-	-	-	-	-	-	-	-	1.32	-
	1956-57	Cobb-Douglas	-	-	-	-	-	-	-	-	-	0.79	-
Sugarcane- planted	1956-57	Cobb-Douglas	-	-	-	12.69	-	-	-	-	-	-	-
Jute	1954-55	Cobb-Douglas	-	-	-	-	-	NS	0.28	-	-	-	-
Cotton (Season II)	1954-55	Cobb-Douglas	-	-	-	-	-	-	-	1.82	-	0.38	-
	1955-56	Cobb-Douglas	-	-	-	-	-	-	-	-	-	0.16	-
	1956-57	Cobb-Douglas	-	-	-	-	-	-	-	-	-	0.27	-

Note: Regression coefficients are significant at 5 per cent level.
** Regression coefficients of bullock labour are significant at 10 per cent level.
@ t-value of the regression coefficientsof bullock labour is greater than one.
- Regression coefficients of bullock labour is not even equal to unity.

studied, sugarcane (planted) in Muzaffarnagar district, Uttar Pradesh, showed the largest marginal value product of bullock labour (Rs. 12.69); and jute in 24-Parganas district, West Bengal gave the lowest marginal value product (Rs. 0.28). When 'farm business as a whole' was considered, the marginal value product was found to be highest (Rs. 4.95) in the district of Meerut, Uttar Pradesh, and the lowest (Rs. 0.71) in Madras. As regards irrigated wheat, the marginal value product of bullock labour was higher in Nasik district than in Ahmednagar district. The productivity of bullock labour also varied from crop to crop within the same region. In Muzaffarnagar district the marginal value product of bullock labour in sugarcane was thrice that in irrigated wheat. In 24-Parganas district of West Bengal, the marginal value product of bullock labour in aus-paddy was larger than in jute. In Coimbatore district of Madras, the marginal value product of bullock labour in irrigated cotton was more than double than in 'farm business as a whole.'

Effect of Other Factors on the Marginal Value Products of Human Labour and Bullock Labour

Not all equations developed in the second run shown in Appendices III and IV were used for studying the effect of other factors on the productivity of human labour and bullock labour. Further screening was done to eliminate the undesirable variables and only those variables whose coefficients were statistically significant at 5 per cent level were retained in the ecuation. The equations developed are given below :

Equation 1 : Farm Business, Nasik (district), Bombay

A. $Y = 1.72290\ X_1^{0.96747}$
(0.07483)

N = 61 C.S.S. = 12.20553 r^2 = 0.73877

B. $Y = 1.46780\ X_2^{0.98028}$
(0.07183)

N = 61 C.S.S. = 12.20553 r^2 = 0.76749

Equation 2 : Farm Business, Ahmednagar district, Bombay

$Y = 3.35178\ X_1^{0.69593}\ X_5^{0.03396}$
(0.02208) (0.00396)

N = 77 C.S.S. = 7.67432 R^2 = 0.50942

Equation 3 : Jowar-unirrigated, Ahmednagar district, Bombay

$Y = 1.41219\ X_1^{1.02783}$
(0.12100)

N = 55 C.S.S. = 6.66015 r^2 = 0.57660

X_1 = the number of human labour days used per acre.
X_2 = the number of bullock labour days used per acre.
X_3 = size of holding in acres.
X_4 = the value of fertilizers and manures used per acre.
X_5 = the percentage of area irrigated in the holding.

N = the number of holdings in the sample.
C.S.S = corrected sum of squares.
r^2 = the coefficient of determination.
R^2 = the coefficient of multiple determination.

The figures in parenthesis denote the Standard Error of the coefficient.
The above notations will be followed throughout this Chapter unless otherwise specified.

Equation 5 : Wheat-unirrigated, Nasik district, Bombay

$$Y = 3.33400\ X_1^{0.80442}$$

(0.15956)

N = 31 C.S.S. = 4.88195 r^2 = 0.46946

Equation 6 : Wheat-irrigated, Nasik district, Bombay

$$Y = 5.73150\ X_1^{1.25787}\ X_2^{-0.58918}$$

(0.06111) (0.05846)

N = 32 C.S.S. = 2.00655 R^2 = 0.48690

Equation 7 : Wheat-irrigated, Ahmednagar district, Bombay

$$Y = 13.72700\ X_2^{0.34804}$$

(0.13439)

N = 35 C.S.S. = 2.52745 r^2 = 0.16890

Equation 8 : Farm Business, Meerut district, Uttar Pradesh

$$Y = 19.95880\ X_1^{0.30503}\ X_2^{0.39151}\ X_4^{0.03597}$$

(0.07484) (0.09273) (0.01659)

N = 100 C.S.S. = 3.93252 R^2 = 0.39816

Equation 11 : Sugarcane (planted), Muzaffarnagar district, Uttar Pradesh

$$Y = 35.73709\ X_1^{0.31550}\ X_2^{0.40755}$$

(0.11770) (0.14430)

N = 78 C.S.S. = 5.33480 R^2 = 0.24660

Equation 16 : Farm Business, 24-Pagranas district, West Bengal

$$Y = 219.03500\ X_2^{0.13453}\ X_3^{-1.25290}$$

(0.02540) (0.02121)

N = 98 C.S.S. = 37.78476 R^2 = 0.78194

Equation 17 : Aman-paddy, Hoogly district West Bengal

$$Y = 13.17400\ X_1^{0.36751}$$

(0.14980)

N = 69 C.S.S. = 2.92642 r^2 = 0.19400

Equation 20 : Jute, Hoogly district, West Bengal

$$Y = 13.49560\ X_1^{0.45609}\ X_3^{0.06232}$$

(0.03565) (0.01553)

N = 46 C.S.S. = 2.92642 R^2 = 0.20991

Equation 21 : Jute, 24-Parganas, district, West Bengal

$$Y = 22.09900\ X_1^{0.41148}\ X_2^{-0.02457}$$

(0.01728) (0.01077)

N = 40 C.S.S. = 1.05218 $\bar{R}^2$ = 0.29465

Equation 22 : Farm Business, Coimbatore district Madras

$$Y = 3.82359\ X_1^{0.66187}\ X_2^{0.19148}$$

(0.04408) (0.04027)

N = 97 C.S.S. = 22.19436 R^2 = 0.55000

Equation 23 : Farm Business, Salem district, Madras

$$Y = 1.73196\ X_1^{0.98221}\ X_3^{0.03376}$$

(0.14500) (0.05146)

N = 94 C.S.S. = 26.41405 R^2 = 0.39757

Equation 24 : Paddy-irrigated (Season I), Madras

$$Y = 12.83340\ X_1^{0.66837}$$

(0.12042)

N = 42 C.S.S. = 6.75181 r^2 = 0.49300

Equation 25 : Paddy-irrigated (Season II), Coimbatore district, Madras.

$$Y = 13.53100\ X_1^{0.59241}$$

(0.26437)

N = 21 C.S.S. = 3.61740 r^2 = 0.72548

Equation 26 : Paddy-irrigated (Season II) Salem district, Madras.

$$Y = 42.23500\ X_1^{0.51133}\ X_3^{-0.35249}$$

(0.03288) (0.06652)

N = 28 C.S.S. = 3.90261 R^2 = 0.53159

Equation 28 : Jowar-irrigated (Season II) Salem district, Madras

$$Y = 4.04710\ X_1^{0.83168}$$

(0.14139)

N = 28 C.S.S. = 6.58419 r^2 = 0.57111

Equation 29 : Cotton-irrigated, Coimbatore district, Madras

$$Y = 5.91939\ X_1^{0.44883}\ X_2^{0.39233}$$

(0.06446) (0.05720)

N = 36 C.S.S. = 12.14606 R^2 = 0.79258

Equation 30 : Cotton-irrigated, Salem district, Madras

$$Y = 2.28396\ X_1^{1.13340}\ X_3^{-0.35300}$$

(0.01705) (0.00790)

N = 21 C.S.S. = 4.40086 R^2 = 0.64627

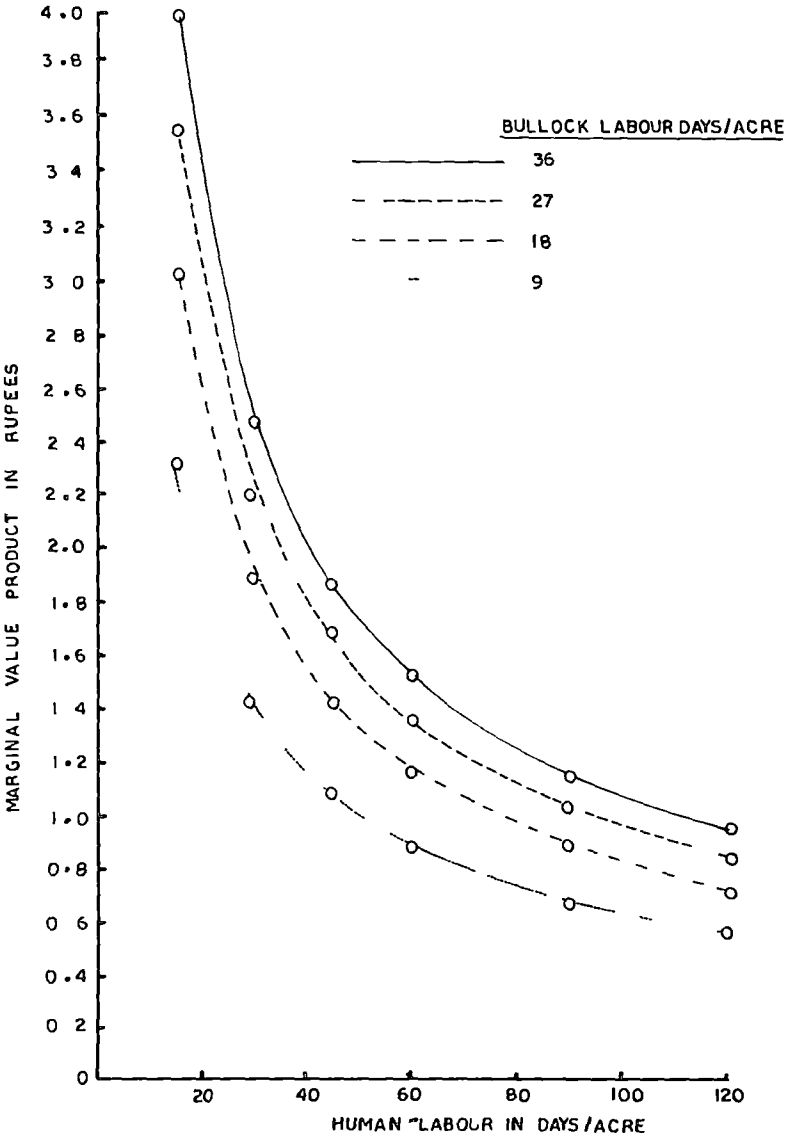
Only the above equations were used for further analysis including the estimation of economic optimum levels of use of human and bullock labour. The effects of bullock labour, size of holding, value of fertilizers, and the percentage of irrigated area in the holding on the marginal productivity of human labour were studied at various levels of human labour (see figures on pages76a, and 76b). The effect of size of holding on the productivity of bullock labour was also studied. The findings are summarized below:

Effect of Bullock Labour Input on the Marginal Value Product of Human Labour :

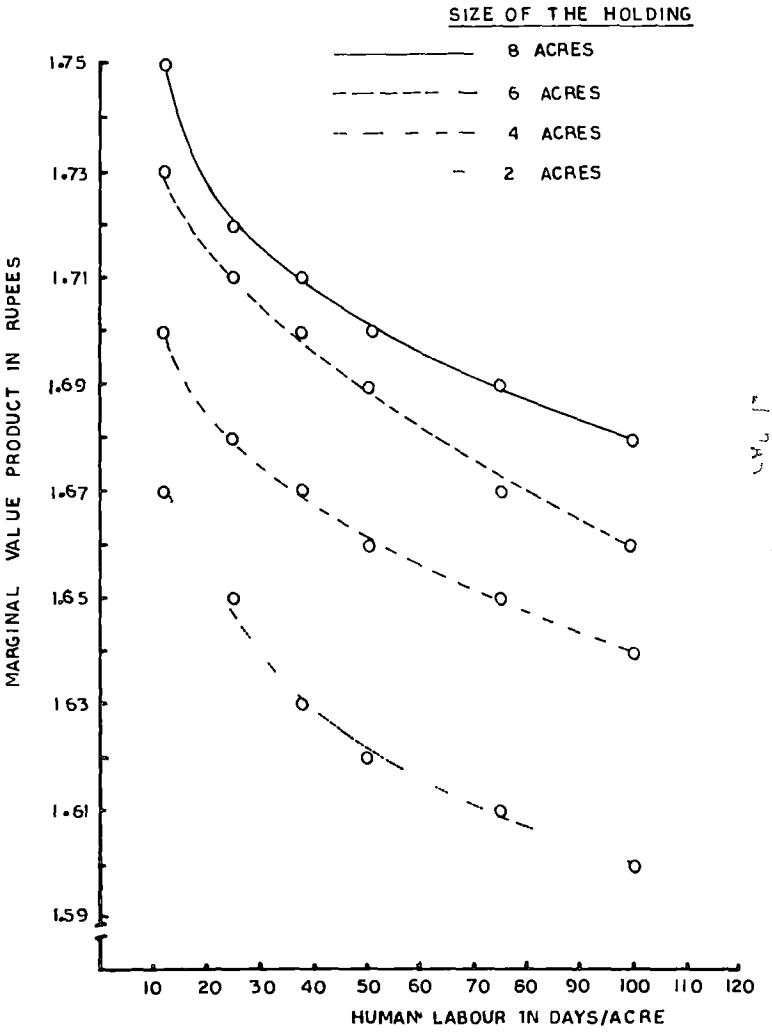
The effect of bullock labour on the productivity of human labour at specific levels of human labour input was studied. For this the marginal value product of human labour input at different (½, ¾, ¾, 1, 1½, and 2 times geometric mean) levels for different levels (½, 1, 1½, and 2 times the geometric mean level) of bullock labour use was estimated. This was done for the 'farm business as a whole' as also with reference to specific crop enterprises in different areas.

In the case of 'farm business as a whole' in Meerut district, Uttar Pradesh, doubling of the input level of bullock

EFFFCT OF BULLOCK LABOUR INPUT ON THE MARGINAL VALUE PRODUCT OF HUMAN LABOUR IN THE FARM BUSINESS OF MEERUT DISTRICT UTTAR PRADESH

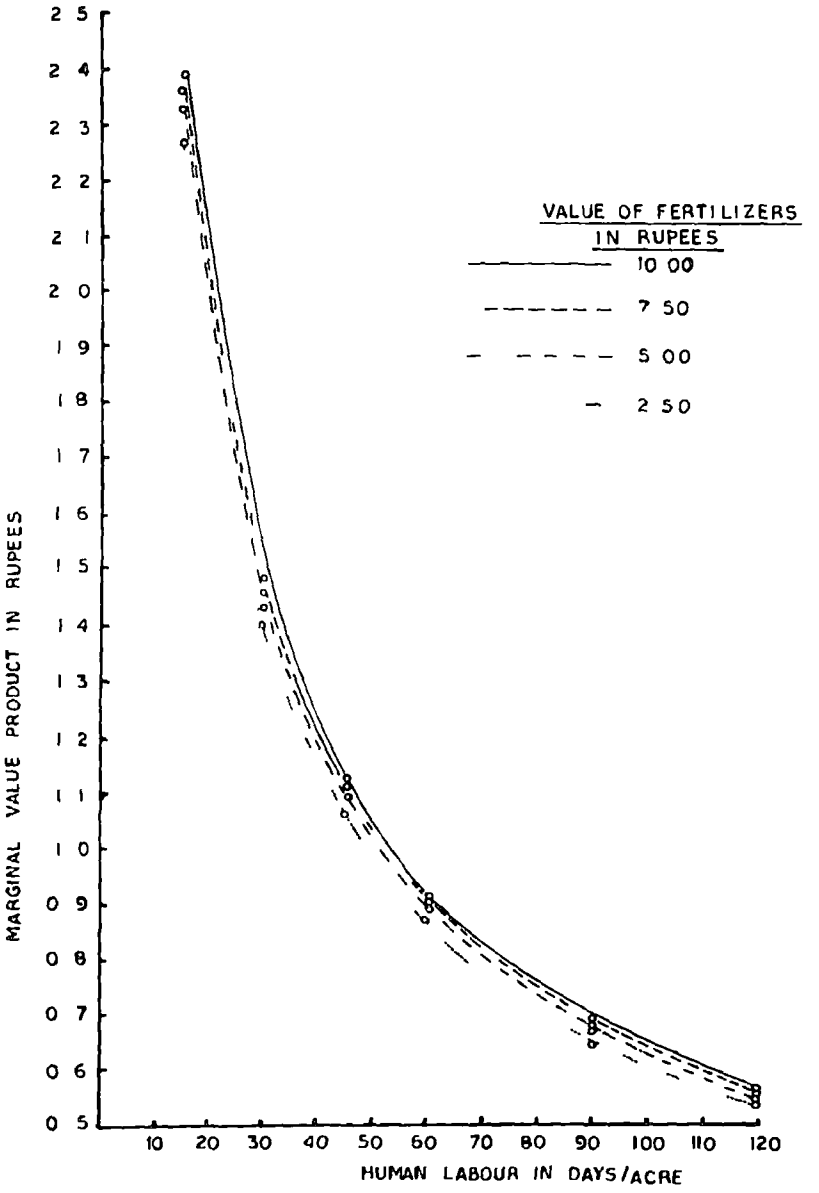


EFFECT OF SIZE OF HOLDING ON THE MARGINAL VALUE PRODUCT OF HUMAN LABOUR IN FARM BUSINESS OF SALEM DISTRICT, MADRAS



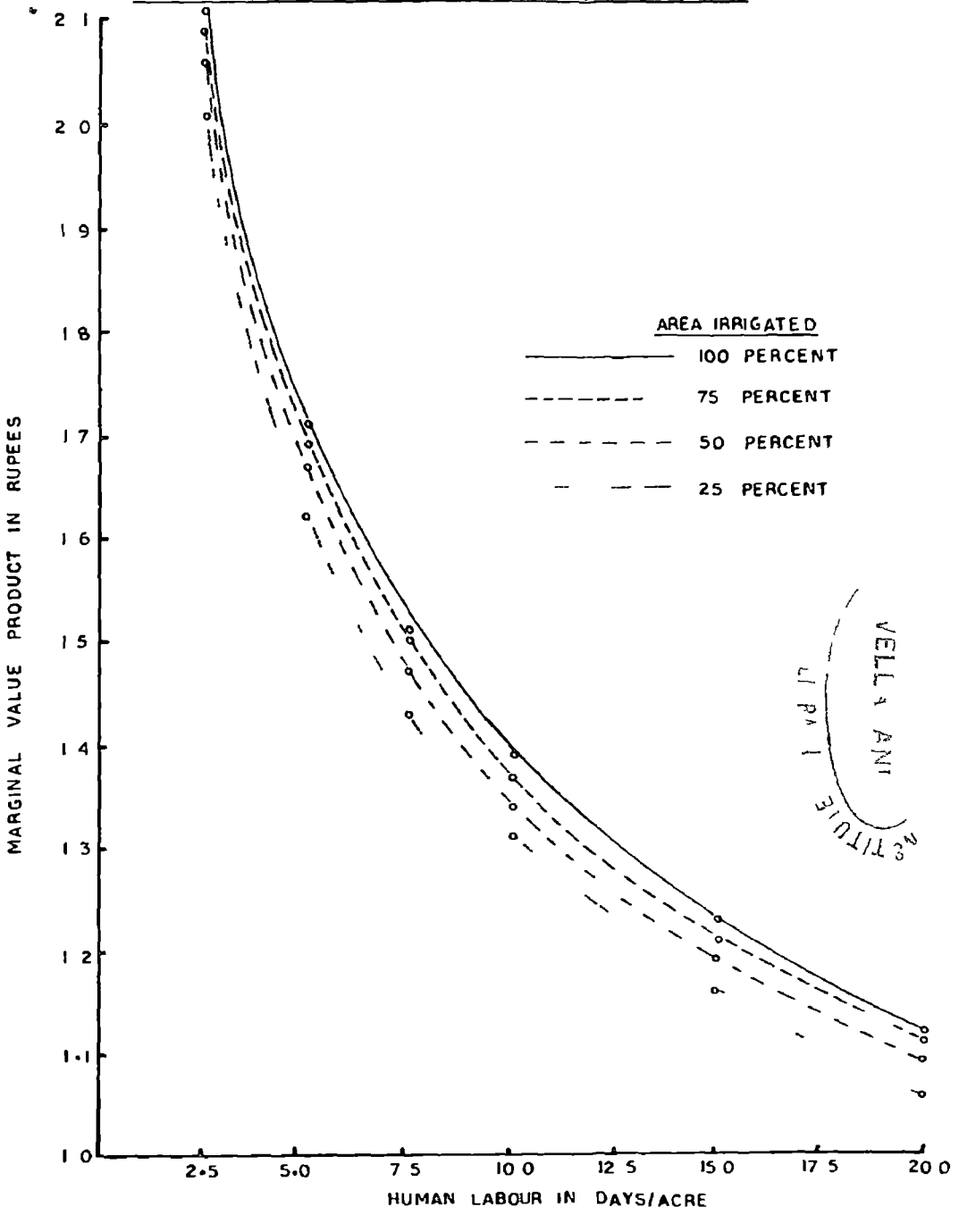
EFFECT OF FERTILIZERS AND MANURES ON THE MARGINAL VALUE PRODUCT OF HUMAN LABOUR

IN FARM BUSINESS, MEERUT DISTRICT, UTTAR PRADESH



EFFECT OF IRRIGATION ON THE MARGINAL VALUE PRODUCT OF HUMAN LABOUR

IN FARM BUSINESS, AHEMDNAGAR DISTRICT, BOMBAY



labour increased the marginal value product of human labour by one third. (Table 13). Holding the human labour at a level of 15 day i.e at ½ of the geometric mean, and raising the bullock labour to a level of 36 days i.e. twice its geometric mean, resulted in an increase in the marginal value product of human labour from Rs. 3.04 to Rs. 3.99 (31 %). At geometric mean level of human labour a similar increase in bullock labour input raised the marginal value product of human labour from Rs. 1.16 to Rs. 1.53 (32 %) and at twice the geometric mean level of human labour input the increase was from Rs. 0.72 to 0.95 (32 %). Keeping the bullock labour constant at geometric mean (18 days) the increase in human labour input from 15 days to 120 days resulted in a four fold decrease of marginal value product of human labour from Rs. 3.04 to Rs. 0.72.

TABLE 13

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND BULLOCK LABOUR IN FARM BUSINESS, MEERUT DISTRICT, UTTAR PRADESH

Bullock labour in days/acre	Human labour in days/acre					
	15	30	45	60 (GM)	90	120
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
9	2.31	1.43	1.08	0.08	0.67	0.55
18 (GM)	3.04	1.88	1.42	1.16	0.88	0.72
27	3.57	2.21	1.67	1.36	1.03	0.84
36	3.99	2.47	1.86	1.53	1.15	0.95

Note: GM refers to Geometric Mean throughout this Chapter.

Similarly the marginal value products of human labour increased at all levels of human labour input when the bullock labour was increased in the farm business of Coimbatore district, Madras (Table No. 14). At ½ geometric mean level of human labour (7 days) the marginal value product of human labour increased from Rs. 2.23 to Rs. 2.55 (14 %) when the bullock labour input was raised from 16 days (Geometric mean level) to 32 days (i.e. twice the Geometric Mean level). For an increase in bullock labour input of the same order (that is double the Geometric Mean level), at the geometric mean level of human labour input (28 days), the increase in marginal value product was increased from Rs. 1.54 to Rs. 1.76 (14 %). Holding the bullock labour input constant at the geometric mean level (16 days) an eight fold increase in human labour input reduced its marginal value product to 55 per cent of its former level from Rs. 2.23 to Rs. 1.22. In Coimbatore as compared with Meerut, with bullock labour held constant, similar order of increase in human labour levelled to a decrease of much lower order in the marginal value product of human labour with human labour held constant, similar proportionate increase in bullock labour use raised the marginal value product much less but the trends were in the same directions.

Among crop enterprises, sugarcane (planted) in Muzaffarnagar district, Uttar Pradesh and irrigated cotton in Coimbatore district, Madras, showed similar behaviour as in the two foregoing instances. At ½th of the geometric mean level of human

TABLE 14

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND BULLOCK LABOUR IN FARM BUSINESS, COIMBATORE DISTRICT, MADRAS

Bullock labour in days/acre	Human labour in days/acre					
	7	14	21	28 (GM)	42	56
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
8	1.95	1.70	1.48	1.34	1.17	1.07
16 (GM)	2.23	1.94	1.69	1.54	1.34	1.22
24	2.41	2.10	1.83	1.66	1.45	1.31
32	2.55	2.22	1.93	1.76	1.53	1.39

labour input in sugarcane (planted) in Muzaffarnagar district, Uttar Pradesh, an increase in bullock labour input from 8 days to 32 days (Geometric mean level = 16 days) raised the marginal value product of human labour by 76 per cent from Rs. 3.64 to Rs. 6.40 (Table 15). The increases in marginal value product of human labour were more or less same at all levels of human labour input. At geometric mean level input the marginal value product of human labour input increased from Rs. 1.41 to 2.48 (76 %) and at twice the geometric mean level from Rs. 0.88 to Rs. 1.54 (75 %) as the bullock labour input increased from 8 days to 32 days. An increase in the input of human labour from 18 days to 144 days (Geometric mean = 72 days) keeping the level of bullock labour input constant, decreased the marginal value product of human labour by nearly four fold at all levels of bullock labour input. In irrigated cotton in Coimbatore

TABLE 15

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND BULLOCK LABOUR IN SUGARCANE (PLANTED), MUZAFFARNAGAR DISTRICT, UTTAR PRADESH

Bullock labour in days/acre	Human labour in days/acre					
	18	36	54	72(GM)	108	144
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
8	3.64	2.26	1.72	1.41	1.07	0.88
16 (GM)	4.83	3.00	2.27	1.86	1.42	1.16
24	5.69	3.54	2.68	2.21	1.67	1.37
32	6.40	3.98	3.02	2.48	1.88	1.54

district, (Table 16) keeping the human labour input at ½th of geometric mean level (i.e. 13 days) the marginal value product of human labour increased from Rs. 1.82 to Rs. 3.14 (72 %) when the bullock labour input (Geometric mean level 28 days) was increased from 14 to 56 days. For a similar increase in bullock labour input keeping the human labour input at geometric mean (52 days) the marginal value product of human labour increased from Rs. 0.85 to Rs. 1.46 (again 72 %). At twice the geometric mean (104 days) the marginal value product increased again by the same fraction from Rs. 0.58 to Rs. 1.00. The proportion of increase remained the same for all levels of human labour input. An increase in the human labour input keeping the bullock labour at a particular level decreased the marginal value product of human labour. The decrease in marginal value product of human labour at all levels of bullock labour input as human labour input increased from 13 days to 104 days was of the

TABLE 16

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND BULLOCK LABOUR IN COTTON-IRRIGATED, COIMBATORE DISTRICT, MADRAS

Bullock labour in days/acre	Human labour in days/acre					
	13	26	39	52(GM)	78	104
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
14	1.82	1.24	0.99	0.85	0.68	0.58
28 (GM)	2.39	1.63	1.30	1.11	0.89	0.76
42	2.80	1.91	1.53	1.30	1.04	0.89
56	3.14	2.14	1.71	1.46	1.17	1.00

order of 68 per cent of the original level.

In irrigated wheat in Nasik district, Bombay and jute in 24-Parganas district, West Bengal, a different behaviour was noted. In the former case (Table 17) increase in bullock labour input from 33 days to 132 days (Geometric mean = 66 days) at all levels of human labour decreased the marginal value product of human labour to 44 per cent of the original level. An increase in the human labour input from 21 days to 170 days (Geometric mean level = 85 days) keeping bullock labour constant on the contrary increased the marginal value product of human labour at all levels of bullock labour input by 71 per cent. In the case of the jute crop in 24-Parganas district, west Bengal (Table 18) for increase in bullock labour from 15 days to 60 days (Geometric mean = 30 days) at all levels of human labour resulted in the decrease of the marginal value product of human

labour to 96 or 97 per cent of the initial level. For all levels of bullock labour input, an increase in human labour input from 30 days to 240 days (Geometric mean = 120 days) drastically decreased the marginal value product of human labour to nearly 28 per cent of the original level. At 15 days of bullock labour input the increase in human labour from 30 days to 240 days decreased its marginal value product from Rs. 1.71 to 0.49. For a similar increase in human labour with bullock labour at twice its geometric mean, the marginal value product of human labour decreased from Rs. 1.65 to Rs. 0.47.

TABLE 17

MARGINAL VALUE PRODUCT OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND BULLOCK LABOUR IN WHEAT-IRRIGATED, NASIK DISTRICT, BOMBAY

Bullock labour in days/acre	Human labour in days/acre					
	21	42	63	85(GM)	126	170
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
33	2.02	2.41	2.68	2.89	3.20	3.46
66 (GM)	1.34	1.60	1.78	1.92	2.13	2.30
99	1.05	1.26	1.40	1.51	1.67	1.81
132	0.89	1.07	1.18	1.28	1.41	1.52

Effect of Size of Holding on the Marginal Value Product of Human Labour :

The marginal value product of human labour was found to increase at all levels of human labour input with an increase in the size of holding in the farm business of Salem district in Madras State (Table 19) but the increase was rather small,

TABLE 18

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND BULLOCK LABOUR IN JUTE IN 24-PARGANAS DISTRICT, WEST BENGAL

Bullock labour In days/acre	Human labour in days/acre					
	30	60	90	120(GM)	180	240
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
15	1.71	1.13	0.90	0.73	0.58	0.49
30 (GM)	1.68	1.12	0.88	0.72	0.57	0.48
45	1.66	1.11	0.87	0.71	0.56	0.47
60	1.65	1.10	0.87	0.71	0.56	0.47

of the order of about 5 per cent over the initial level. At ½th geometric mean level of human labour input (12.50 days) the increase in the size of holding from 2 acres to 8 acres resulted in the increase of marginal value product of human labour from Rs. 1.68 to Rs. 1.75. For the same increase in the size of holding at twice the geometric mean of human labour input the increase remained more or less the same. At all size levels, an increase in human labour input (Geometric mean level = 50 days) from 12.5 days to 100 days resulted in a 3 to 4 per cent decrease in the value of the marginal value product of human labour. When a Quadratic Function instead of a function of the Cobb-Douglas Type was fitted (Table 20), the trends were in the same direction. However in this case as the size of holding increased from 2 to 8 acres the marginal value product of human labour rose sharply, the rise being steeper as the level of

TABLE 19

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND FOR VARIOUS SIZES OF HOLDINGS IN FARM BUSINESS, SALEM DISTRICT, MADRAS (COBB-DOUGLAS TYPE OF FUNCTION)

Size of holding in acres	Human labour in days/acre					
	12½	25	37½	50(GM)	75	100
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
2	1.67	1.65	1.63	1.62	1.61	1.60
4 (GM)	1.70	1.68	1.67	1.66	1.65	1.64
6	1.73	1.71	1.70	1.69	1.67	1.66
8	1.75	1.72	1.71	1.70	1.69	1.68

TABLE 20

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND FOR VARIOUS SIZES OF HOLDINGS IN FARM BUSINESS, SALEM DISTRICT, MADRAS (QUADRATIC TYPE OF FUNCTION)

Size of holding in acres	Human labour in days/acre					
	12½	25	37½	50(GM)	75	100
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
2	0.44	0.31	0.25	0.19	0.07	-0.05
4 (GM)	1.31	1.19	1.12	1.06	0.94	0.82
6	2.18	2.06	1.99	1.93	1.81	1.69
8	3.05	2.93	2.87	2.81	2.68	2.56

human labour use rose (593 per cent at 12½ days of human labour to 1380 per cent at 75 days of human labour). This steep rise was in evidence since the estimated marginal value product was much lower at low size levels and much higher at higher size levels in contrast to the estimates obtained in the Cobb-Douglas Type of Functions.

Similarly with jute in Hoogly district of West Bengal, increase in size of holding from 1 to 4 acres (Geometric mean = 2 acres) resulted in the increase of marginal value productivity of human labour at all levels of the order of about 9 per cent over the lowest size (Table 21). At ½th geometric mean level of human labour input (22.50)days) the increase in the size of holding from 1 acre to 4 acres increased the marginal value product of human labour from Rs. 1.13 to Rs. 1.23. For a similar increase in the size of holding for 110 days of human labour, the value of marginal product of human labour increased from Rs. 0.48 to Rs. 0.52 and for 220 days from Rs. 0.33 to Rs. 0.36.

Farm Business analysis in 24 Parganas district of West Bengal (Table 22) showed a different behaviour than that described above; an increase in the size of holding decreased the marginal productivity of human labour. At ½ geometric mean of human labour the increase in the size of holding from one acre to 4 acres resulted in the decrease of marginal value productivity of human labour from Rs. 5.98 to Rs. 0.70. At the geometric mean of human labour input the increase in size of holding from one acre to four acres resulted in negative marginal value product of human labour.

TABLE 21

MARGINAL VALUE PRODUCT OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND FOR VARIOUS SIZES OF HOLDINGS IN JUTE IN HOOGLY DISTRICT, WEST BENGAL

Size of holding in acres	Human labour in days/acre					
	22½	55	77½	110 (GM)	165	220
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
1	1.13	0.70	0.58	0.48	0.38	0.33
2 (GM)	1.17	0.73	0.60	0.50	0.40	0.34
3	1.21	0.75	0.62	0.51	0.41	0.35
4	1.23	0.76	0.63	0.52	0.42	0.36

TABLE 22

MARGINAL VALUE PRODUCT OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND FOR VARIOUS SIZES OF HOLDINGS IN FARM BUSINESS, 24-PARGANAS DISTRICT, WEST BENGAL (WITH QUADRATIC TYPE OF FUNCTION)

Size of holding in acres	Human labour in days/acre					
	16	32	48	64(GM)	96	128
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
1	5.98	5.67	5.37	5.06	4.75	4.44
2 (GM)	4.22	3.91	3.60	3.30	2.99	2.68
3	2.46	2.14	1.84	1.54	1.23	0.92
4	0.70	0.39	0.08	-0.22	-0.53	-0.84

Decrease in the marginal value products of human labour was also seen in irrigated paddy and irrigated cotton in Salem district of Madras state as the size of holding increased. An increase in the size of holding from 2½ acres to 10 acres at ¼th of the geometric mean level of human labour, decreased the marginal value product of human labour from Rs. 3.24 to Rs. 1.99 in irrigated paddy of Salem district (Table 23). At geometric level the decrease in the productivity of human labour was from Rs. 1.65 to Rs. 1.01 for a similar increase in the size of holding. At twice the geometric mean a similar increase in size of holding resulted in the decrease of marginal value product from Rs. 1.17 to Rs. 0.72.

TABLE 23

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND FOR VARIOUS SIZES OF HOLDINGS IN PADDY (IRRIGATED), SALEM DISTRICT, MADRAS

Size of holding in acres	Human labour in days/acre					
	25	50	75	100 (GM)	150	200
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
2½	3.24	2.31	1.90	1.65	1.35	1.17
5 (GM)	2.54	1.81	1.49	1.29	1.06	0.92
7½	2.20	1.57	1.29	1.12	0.92	0.80
10	1.99	1.42	1.16	1.01	0.83	0.72

In irrigated cotton in Salem district, Madras increase in size of holding from 2 acres to 8 acres decreased the marginal value product from Rs. 3.61 to Rs. 2.21 with human labour held at a level of 21 days (Geometric mean = 84 days). At 84 days level of human labour input, increase in the size of holding of the same order decreased the marginal value product from Rs. 4.31 to Rs. 2.64 (Table 24). At twice the geometric mean level of human labour days (168 days) marginal value product decreased from Rs. 4.73 to Rs. 2.90.

TABLE 24

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND FOR VARIOUS SIZES OF HOLDINGS IN COTTON (IRRIGATED), SALEM DISTRICT, MADRAS

Size of holding in acres	Human labour days/acre					
	21	42	63	84(GM)	126	168
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
2	3.61	3.96	4.18	4.31	4.55	4.73
4 (GM)	2.82	3.10	3.27	3.37	3.56	3.70
6	2.45	2.69	2.83	2.92	3.09	3.21
8	2.21	2.43	2.56	2.64	2.78	2.90

Effect of Fertilizers and Manures on the Marginal Value Product of Human Labour :

The marginal value product of human labour increased with the increase in the level of fertilizers and manures used in the farm business of Meerut district, Uttar Pradesh. However, the increase was not considerable (Table 25). At $\frac{1}{4}$th geometric mean level of human labour input, an increase in the value of fertilizers and manures used from Rs. 2.50 to Rs. 10.00 increased

TABLE 25

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND FOR VARIOUS LEVELS OF FERTILIZERS AND MANURES USED IN FARM BUSINESS, MEERUT DISTRICT, UTTAR PRADESH

Value of fertilizers and manures in rupees	Human labour in days/acre					
	15	30	45	60(GM)	90	120
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
2½	2.27	1.40	1.06	0.87	0.65	0.54
5 (GM)	2.33	1.44	1.09	0.89	0.67	0.55
7½	2.36	1.46	1.11	0.90	0.68	0.56
10	2.39	1.48	1.12	0.91	0.69	0.57

of human labour from Rs. 2.27 to Rs. 2.39. At 60 days level of human labour input (Geometric mean level) a similar increase in fertilizer use raised the marginal value product of human labour from Rs. 0.87 to Rs. 0.91. At 120 days level of human labour the same increase in the input of fertilizers resulted in the increase of marginal value product of human labour from Rs. 0.54 to Rs. 0.57.

Effect of Irrigation on the Marginal Value Product of Human Labour :

It was found that as the percentage of area under irrigation increased, the marginal value product of human labour also increased at all levels of human labour although here too, the increase was not considerable (Table 26). In farm business analysis of Ahmednagar district, Bombay at ¼th geometric mean level of human labour input (2.50 days) the increase in the area

TABLE 26

MARGINAL VALUE PRODUCTS OF HUMAN LABOUR AT DIFFERENT INPUT LEVELS OF HUMAN LABOUR AND FOR DIFFERENT LEVELS OF AREA UNDER IRRIGATION IN FARM BUSINESS, AHMEDNAGAR DISTRICT, BOMBAY

Area under irrigation in percentage	Human labour in days/acre					
	2½	5	7½	10(GM)	15	20
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
25	2.01	1.62	1.43	1.31	1.16	1.06
50	2.06	1.67	1.47	1.34	1.19	1.09
75	2.09	1.69	1.50	1.37	1.21	1.11
100	2.11	1.71	1.51	1.39	1.23	1.12

irrigated from 25 per cent to 100 per cent raised the marginal value product from Rs. 2.10 to Rs. 2.11. For the same increase in the percentage area irrigated at geometric mean level of human labour (10 days) the marginal value product of human labour increased from Rs. 1.31 to Rs. 1.39. At twice the geometric mean for a similar increase in the area under irrigation raised the marginal value product of human labour from Rs. 1.06 to Rs. 1.12.

Effect of Size of Holding on the Marginal Value Product of Bullock Labour :

The effect of size of holding on the marginal value product of bullock labour was studiedin the farm business of 24-Parganas district, West Bengal. Increase in the size of holding for all levels of human labour input decreased the marginal value product of bullock labour (Table 27). At ½th the geometric mean level of input of bullock labour (35 days)

TABLE 27

MARGINAL VALUE PRODUCTS OF BULLOCK LABOUR AT DIFFERENT INPUT LEVELS OF BULLOCK LABOUR AND FOR DIFFERENT SIZES OF HOLDINGS IN FARM BUSINESS IN 24-PARGANAS DISTRICT, WEST BENGAL

Size of holding in acres	Bullock labour in days/acre					
	35	70	105	140(GM)	210	280
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
1	10.88	6.00	4.16	3.28	1.72	1.12
2 (GM)	4.56	2.48	1.76	1.36	0.96	0.80
3	2.72	1.52	1.04	0.80	0.56	0.48
4	1.92	1.04	0.72	0.56	0.40	0.32

Note: The above table was prepared from Equation Number 16 which is given below.

$$Y = 219.03500\ X_2^{\underset{(0.02540)}{0.13453}}\ X_3^{\underset{(0.02121)}{-1.25290}}$$

the increase in size of holding from 1 acre to 4 acres decreased the marginal value product from Rs. 10.88 to Rs. 1.92. At geometric mean level of bullock labour, the same increase in size of holding decreased the marginal value product of bullock labour from Rs. 3.28 to Rs.0.56. At twice the geometric mean level (280 days) of bullock labour the marginal value product of bullock labour decreased from Rs. 1.1 to Rs. 0.32 when the size of holding increased from 1 acre to 4 acres. For all sizes of holding the marginal value product of bullock labour decreased with the increase in the input of bullock labour.

Economic Optimum Levels

The method of determining economic optimum levels of the inputs has already been described in the Chapter dealing with Methodology. As an illustration, the steps involved are described below:

Equation 22 : Farm Business, Coimbatore district Madras

$$Y = 3.82359\ X_1^{0.66187}\ X_2^{0.19148}$$

where Y = the return in rupess per acre

X_1 = the input of human labour in days per acre.

X_2 = the input of bullock labour in days per acre.

After taking the partial derivatives with respect to each input and equating the partial derivative function to their corresponding input price (Rupess 0.95 and Rs. 1.07 for human labour and bullock labour respectively).

$$0.95 = \frac{dY}{dX_1.X_2} = 3.82359\ (0.66187)\ X_1^{-0.33813}\ X_2^{0.19148}$$

$$1.07 = \frac{dY}{dX_2.X_1} = 3.82359\ (0.19148)\ X_2^{-0.80852}\ X_1^{0.66187}$$

Converting theequations to logarithmic form, we get,

$$\bar{1}.97772 = 0.58247 + \bar{1}.82078 - 0.33813\ X_1 + 0.19148\ X_2$$

$$0.00938 = 0.58247 + \bar{1}.28212 - 0.80852\ X_2 + 0.66187\ X_2$$

By solving these equations simultaneously for X_1 and X_2, we get

$X_1 = 2.21814$

$X_2 = 1.63675$

The antilogarithms of these values give the respective economic optimum levels as follows:

X_2 = 43.327 which is equal to 43 days of human labour per acre

X_1 = 165.25 which is equal to 165 days of human labour per acre.

Equation 5 : Wheat-unirrigated, Nasik district, Bombay.

$$Y = 8.81736 + 4.44912 X_1 - 2.71647 X_2 - 0.31771 X_3 - 0.03233 X_1^2 + 0.02448 X_2^2 - 0.01736 X_3^2 + 0.01124 X_1 X_3 - 0.13480 X_1 X_3 + 0.15338 X_2 X_3$$

where Y = the return in rupees per acre

X_1 = the input of human labour in days per acre

X_2 = the input of bullock labour in days per acre.

X_3 = the size of holding in acres.

After taking the partial derivatives with respect to each input and equating the partial derviative function to their corresponding input price (Rs. 0.92 and Rs. 0.96 for human labour and bullock labour respectively).

$$0.92 = 4.44912 - 0.06466 X_1 + 0.01124 X_2 - 0.13480 X_3$$

$$0.96 = -2.71647 + 0.04896 X_2 + 0.01124 X_1 + 0.15338 X_3$$

Substituting the value of X_3 (the geometric mean = 12.57) in the above equations and solving for X_1 and X_2 we get the economic optimum levels of human labour and bullock labour.

X_1 = 29.68/ = 30 days of human labour days per acre

X_2 = 12.91/ = 13 days of bullock labour per acre

The economic optimum levels of human labour were determined for certain selected enterprises and the results are summarised in Table 28. Similarly the economic optimum levels of bullock labour were also determined for certain selected enterprises and the results are summarized in Table 29.

Economic Optimum Levels of Human Labour

Economic optimum levels were lower than the geometric means of human labour input in farm business of Meerut district and crop enterprises in both the districts of West Bengal. Marginal analysis has already shown that for most of the enterprises in these two states, the marginal value products were lower than the prevailing wage rates. Hence reduction in labour input would be necessary to bring down to the level of economic optimum. The analysis has also shown that the marginal value productivities of human labour in all the enterprises of Bombay and Madras were greater than the prevailaing wage rates. Hence in all such enterprises there was scope for increasing the input of human labour and, therefore, the economic optimum levels were higher than the geometric mean level of present use.

In the farm business of Nasik district, 8 labour days were used per acre. Since the wage rate was lower than the marginal value product, increasing the human labour input upto 2½ times of the present level would bring more profit to the

Table 28

ECONOMIC OPTIMUM LEVELS OF HUMAN LABOUR FOR SELECTED ENTERPRISES

Equation No.	Enterprise	Geometric mean (days)	Economic optimum (days)	Wage rate (Rs./day)	Marginal value product (Rs.)
1	Farm Business, Nasik (District) Bombay	7.98	20.47	0.92	1.56
8	Farm Business, Meerut (District) Uttar Pradesh	59.80	34.67	1.25	1.17
17	Aman-paddy, Hoogly (District) West Bengal	24.61	8.03	1.55	0.64
20	Jute, Hoogly (District) West Bengal	109.36	77.00	1.55	1.28
21	Jute, 24-Parganas (District) West Bengal	119.00	19.10	2.44	0.88
26	Paddy-irrigated (Season II) Salem (District) Madras	97.95	117.50	0.96	1.30

farmer. In the farm business of Meerut district the existing input use level of human labour would have to be halved in order to attain the economic optimum level. Reduction to nearly ½rd of the existing level of use of human labour was needed to attain the economic optimum in case of aman paddy in Hoogly district of West Bengal. The wage rate was nearly 2½ times the marginal value product of human labour for Aman-paddy in the Hoogly district of West Bengal. In jute cultivation of Hoogly district in West Bengal human labour input would have reduced to ⅔rd of

TABLE 29

ECONOMIC OPTIMUM LEVELS OF BULLOCK LABOUR FOR SELECTED ENTERPRISES

Equation No.	Enterprise	Geometric mean (days)	Economic optimum (days)	Wage rate (Rs./day)	Marginal value product (Rs.)
7	Wheat-irrigated, Ahmednagar (District) Bombay	53.46	78.71 24.24+	0.48 1.05+	0.62
8	Farm Business, Meerut (District), Uttar Pradesh	17.98	8.17	6.10	4.95
16	Farm Business, 24-Parganas (District) West Bengal	17.25	14.45	1.86	1.60
18	Aus-paddy, Hoogly (District) West Bengal	18.01	(29.41)	1.41	2.09
22	Farm Business, Coimbatore (District) Madras	15.76	43.33	0.56	0.71

\+ Economic optimum level calculated on the basis of cost of hired bullock labour per day.

Figures in parenthesis are the marginal value products estimated from Quadratic Functions.

its current level to bring it to the optimum level while in the jute cultivation of 24-Parganas district the human labour input per acre has to be cut to 1/6th to bring it down to the economic optimum level. In 24-Parganas district, the marginal value product was lower and the wage rate higher than in Hoogly district.

Economic Optimum Levels of Bullock Labour

In the farm business of Meerut district, Uttar Pradesh and 24-Parganas district, West Bengal, the economic optimum levels were lower than the respective geometric mean of bullock labour input. The bullock labour input would have to be reduced to half in the farm business of Meerut, Uttar Pradesh, to attain the economic optimum level. In the farm business of 24-Parganas district, West Bengal, the reduction of three bullock labour days was needed to attain the economic optimum level.

In the farm business of Coimbatore district, Madras economic optimum levels of bullock labour was higher than the geometric mean of bullock labour input. Nearly trebling the input level was needed to bring it up to the economic optimum level in the farm business of Coimbatore district, Madras. In irrigated wheat of Ahmednagar district, Bombay if the farmer were to use his own bullock labour he could use still more of them to attain economic optimum. The economic optimum levels of bullock labour use was lower for those farmers who hired the bullock labour because in Ahmednagar district, the hired bullock labour had twice the price of that of farmers' own bullock labour.

CHAPTER VIII

CONCLUSIONS AND SUGGESTIONS

Before presenting conclusions from the findings, it appears necessary to discuss some of the problems of interpretation of the findings, which call for the exercise of caution in drawing strong inferences from these findings.

In the course of the study, the original number of 60 equations became reduced to 11 for the final analysis. This points to the problems of using farm level data for the fitting of production functions. The suspected cause for the large rate of attrition among the functions included at the start could be: non-specification of relevant variables, randomness of the relationship and limitations of the statistical model when the assumedly independent variables are inter-correlated. This latter has resulted in the necessity to eliminate from the functions many variables which on apriori grounds would be expected to influence output. Some of these problems of multicollinearity are reflected by the conclusions drawn from the correlation analyses, presented below:

Gross returns per acre were found to be highly correlated with per acre inputs of human and bullock labour. This could be expected to hold generally in an agriculture as in India, where these two inputs represent a very large portion of inputs, when land is excluded. Positive correlation was also found between per acre returns and the inputs of fertilizers and manures and irrigation. The correlation between yield per acre and size of holding was found mostly to be negative and low.

This finding also conforms with general expectations for economies of scale in agricultural production in relation to gross returns.

When the interrelationship between assumedly independent variables was examined, high inter-correlation was noted between the inputs of human labour and bullock labour. This again is in line with general findings and it frequently necessitated the dropping of one or the other from the equations retained for further analysis. The size of holding was found to be negatively correlated with the levels of human and bullock labour use, and the correlation was low.

On the basis of the findings of the production function analysis, the hypothesis that marginal value products of human labour and bullock labour vary from region to region and between crop to crop within the region is accepted. The marginal value products worked out for the 'farm business as a whole' and for various enterprises in different regions, shown in Tables 10 and 12 lend support to this hypothesis.

Considering the'farm business as a whole,'the range of marginal valuepproducts of human labour extended from Rs.1.18 in Ahmednagar district, Bombay to Rs. 4.37 in Punjab. This nearly four-fold difference in marginal value productivities may be due to the differences in soils and in availability irrigation facilities; both of them being heavily in favour of the Punjab in comparison with Ahmednagar district, Bombay.

There were also regional variations observed in marginal value product of human labour applied to the same crop.

Thus the marginal value product of human labour in the production of paddy in Hoogly district, West Bengal was only Rs. 0.64, while it was Rs. 1.24 in Coimbatore district, Madras.

The marginal value product varied between crops and also between irrigated and non-irrigated situations for the same crops within the same region. For instance, in Muzaffarnagar district of Uttar Pradesh, the marginal value product of human labour for sugarcane (planted) and irrigated wheat were Rs. 1.87 and Rs. 2.34 respectively. The marginal value product of human labour varied in jute and paddy production in the Hoogly district of West Bengal and the values were Rs. 0.64 and Rs. 1.28 respectively.

The marginal value products of bullock labour were also found to vary between different regions. As could be seen from the Tables 11 and 12, for the 'farm business as a whole,' marginal value products of bullock labour varied from Rs. -2.00 in the Punjab to Rs. 4.95 in Meerut district, Uttar Pradesh.

The marginal value product of bullock labour varied between crops within the region also. In Muzaffarnagar district of Uttar Pradesh, the marginal value product for bullock labour in sugarcane (planted) was Rs. 12.69 while it was only Rs. 3.40 in irrigated wheat. In Madras both the districts combined, the marginal value product of bullock labour was Rs. 1.85 in irrigated jowar, while it was only Rs. 0.38 in irrigated cotton.

These crop-to-crop differences within the same area, between the marginal value productivity of both human and

bullock labour appear to be large and would suggest possibilities for increased earnings by shifting labour from one enterprise to the other. However, there is one important consideration which limits these opportunities. This is the seasonality of agricultural production, which often results in non-competitive, but supplementary relationships between crop enterprises with reference to labour , especially if this labour is fixed for the farm.

The hypothesis that the marginal value products of human labour are affected by the inputs of bullock labour, fertilizers and manures and other factors, such as size of holding, percentage of area irrigated, is accepted on the basis of the findings detailed in Chapter VII subsection iv.

Increase in the bullock labour input at different levels of human labour was found to increase the marginal value products of human labour in the farm business as a whole in Meerut district, Uttar Pradesh, and in Coimbatore district, Madras. In individual enterprises it resulted in increase in sugarcane (planted) in Muzaffarnagar district, Uttar Pradesh and in irrigated cotton in Coimbatore district, Madras. However, in irrigated wheat of Nasik district, Bombay and in jute of 24-Paraganas district, West Bengal, the marginal value products of human labour were found to decrease with the increase in the inputs of bullock labour. The decrease was sizeable and rapid in the former, while it was nominal and slow in the latter. Some caution may be used in attaching weight to the relationship between inputs of human and bullock labour, because

in the correlation analysis they have been found to be highly correlated in many of the cases and thus their combined effects may make estimation of independent marginal value products difficult. It is also possible, that further increases of the already high bullock labour input (66 bullock labour days per acre) on irrigated wheat in Nasik district fell into the third stage of the production function with negative returns to this factor and thus depressed the yields.

In the analysis of the 'farm business as a whole' of Meerut District, Uttar Pradesh it was found that the increase in the inputs of fertilizers and manures increased the marginal value products of human labour though the rise was slow and small (Table 25). The small increases in labour productivity with increase in manures and fertilizers may be attributed to the fact that levels of use for fertilizer and manures were very low, compared to recommendations, even at double the geometric mean level of actual use. The analysis of the 'farm business as a whole' of Ahmednagar district, Bombay showed that the increase in the percentage of area irrigated, resulted in an increase in marginal value product of human labour (Table 26).

The hypothesis on the effect of size of holding on the marginal value product of bullock labour could not be fully tested because the number of equations developed in the process of analysis were not sufficient. In the analysis of 'farm business as a whole,' of 24-Parganas district, West Bengal, it was found that increase in the size of holding

depressed the marginal value product of bullock labour (Table 27). This result was contradictory to expectations.

The hypothesis that marginal value product of human labour decreased with the increase in the inputs of human labour was found to be true in a number of cases except in irrigated wheat of Nasik district, Bombay and irrigated cotton of Salem district, Madras.

The last hypothesis that marginal value product at geometric mean level is different from the prevailing unit prices of inputs and, therefore, is different from the economic optimum levels of human labour and bullock labour, is accepted. In Meerut district of Uttar Pradesh and in West Bengal, in most of the cases, the marginal value product of human labour was lower than the wage rate. The economic optimum levels of human labour and bullock labour were therefore lower than the geometric mean of input levels. Such an apparent disequilibrium may be explained by considering the marginal value product only of those farmers who do employ wage labour. Because usually these farms are larger, one could expect that the marginal value product of human labour on them would be higher than on small farms thus this higher marginal value product could be equal to the going wage rate in the area. Also the marginal value product is an average for all the operations on the farm or on the crop, while wage-labour is usually employed only at peak seasons, in which operations, one could

expect marginal productivity to be higher than for all labour used. These two hypotheses may also help to explain why in certain individual crops wage rates differ significantly from marginal value product for the same crops.

In Madras, however, the wage rates (1954-55) were lower than the marginal value products ofhhuman labour at its geometric mean. The economic optimum level of human labour was higher than the human labour input at its geometric mean.

The findings in this study are not conclusive enough to lend support to the hypothesis suggested by Hopper that the marginal value product of human labour is approximately equal to the ruling wage rate. This theory holds good in the farm business of Meerut and Ahmednagar districts; but not in the crop enterprises of West Bengal and Madras. In most of the individual crop enterprises the marginal value products considerably differed from the prevailing wage rates.

In all the enterprises the marginal value products of human labour were found to be positive at the geometric mean level of input. The marginal value products of human labour became negative, only after the human labour input increased to a level more than twice its geometric mean. The results obtained in this study support the hypothesis that marginal value product of human labour in densely populated low income countries is still positive, as propounded by Mellor and Jorgenson. The findings of the study also support the conclusion of Hanumantha Rao that marginal productivity of human labour is positive and significant in this country.

The difference in the marginal value product of human labour between crops within the region could be exploited by the farmers. For instance in Nasik district, Bombay farmers could shift labour from unirrigated to irrigated wheat and thereby increase their incomes. Similarly in Coimbatore district, Madras, shifting labour from irrigated cotton to irrigated paddy (Season II) and in Salem district, Madras from irrigated paddy to irrigated cotton were found to be paying adjustments.

For policy making at the national level, the difference in marginal value products can be made use. For instance, shifting labour from agricultural sector would result in lesser loss in West Bengal than Bombay or Madras, because marginal value product of human labour was larger in Bombay and Madras than in West Bengal.

Since the marginal value products of human labour at geometric mean were positive, the farmers can employ family labour so long as it does not result in negative product and also if the farm family labour does not have alternative opportunities for outside jobs.

APPENDIX I

FIRST TRIAL EQUATIONS OF REGRESSION ANALYSIS

(QUADRATIC FUNCTIONS)

EQUATION 1 Farm Business - Nasik District, Bombay

$$Y = 0.26594 + 1.01478\ X_1 + 0.66550\ X_2 - 0.00992\ X_3 - 0.25404\ X_4^{**} + 0.08290\ X_1^{2\,*} + 0.06728\ X_2^{2**} + 0.00009\ X_3^2 - 0.15522\ X_1X_2\,^{*} - 0.00914\ X_1X_3 + 0.01691\ X_2X_3$$

(1.30414) (1.23004) (0.30857)

(0.16344) (0.01626) (0.03763)

(0.00323) (0.04923) (0.03949)

(0.03619)

$N = 61$ $R^2 = 0.91161$ P.C.V. = 91.16 C.S.S. = 41511.731

R.S.S. = 37842.384

Y	=	Output per acre in rupees.
X_1	=	Human labour days per acre.
X_2	=	Bullock labour days per acre.
X_3	=	Size of holding in acres.
X_4	=	Value of manures and fertilizers per acre in rupees.
X_5	=	Percentage of area under irrigation.
N	=	Number of holdings in the sample.
R^2	=	Coefficient of multiple determination.
P.C.V.	=	Percentage variation explained by the independent variables included in the function.
C.S.S.	=	Corrected sum of squares.
R.S.S.	=	Regression sum of squares.
	*	Significant at 5 per cent level
	**	Significant at 10 per cent level

Note: The above notations will be followed throughout unless otherwise specified.

EQUATION 2 Farm Business - Ahmed nagar (District), Bombay

$$Y = -4.23545 + 1.76542\ X_1\ ^{**} + 0.04297\ X_2 + 0.46966\ X_3\ @ + 0.02342\ X_5 + 0.04840\ X_1^2\ ^{**} + 0.07522\ X_2^2\ ^{**} - 0.00388\ X_3^2 - 0.13634\ X_1X_2\ ^{**} + 0.01183\ X_1X_3 - 0.02567\ X_2\ X_3$$

(0.98725) (0.78944) (0.41446) (0.08031) (0.02676) (0.03806) (0.04406) (0.07062) (0.03530) (0.02802)

N = 77 R^2 = 0.69798 P.C.V. = 69.80 C.S.S. = 26439.311 R.S.S.= 18454.071

EQUATION 3 Jowar-unirrigated - Ahmed nagar (District) Bombay

$$Y = -0.87060 + 3.06400\ X_1\ ^{*} - 1.57972\ X_2\ @ + 0.01472\ X_3 - 0.00607\ X_1^2 + 0.00695\ X_2^2 - 0.00234\ X_3^2 - 0.01059\ X_1\ X_2 + 0.00877\ X_1\ X_3 + 0.01818\ X_2\ X_3$$

(1.26506) (1.50752) (0.72675) (0.03933) (0.10913) (0.00713) (0.14102) (0.02092) (0.03794)

N = 55 R^2 = 0.73010 P.C.V. = 73.01 C.S.S. = 35502.873 R.S.S = 25920.820

@ t-value is greater than unity.

EQUATION 4 Jowar-irrigated - Ahmed nagar (District) Bombay

$$Y = -19.29356 + 7.10046\ X_1\ ^{*} - 4.18456\ X_2\ ^{**} - 1.57223\ X_3 - 0.04432\ X_1^2\ @ - 0.01088\ X_2^2 + 0.05846\ X_3^2\ ^{**} + 0.5084\ X_1\ X_2\ @ - 0.10188\ X_1\ X_3\ ^{**} + 0.11430\ X_2\ X_3\ ^{**}$$

(3.10274) (2.35252) (2.77621) (0.03745) (0.01104) (0.03883) (0.03690) (0.05809) (0.05170)

N = 50 R^2 = 0.58527 P.C.V. = 58.53 C.S.S. = 281201.310

R.S.S. = 0164580040.

EQUATION 5 Wheat-unirrigated - Nasik (District) Bombay

$$Y = 8.81736 + 4.44912\ X_1\ ^{*} - 2.71647\ X_2\ ^{**} - 0.31771\ X_3 - 0.03233\ X_1^2 + 0.02448\ X_2^2 - 0.01736\ X_3^2 + 0.01124\ X_1\ X_2 - 0.13480\ X_1\ X_3\ ^{**} + 0.15338\ X_2\ X_3\ ^{**}$$

(1.86339) (1.83550) (1.63367) (0.04077) (0.05320) (0.02211) (0.09660) (0.06994) (0.08849)

N = 31 R^2 = 0.97632 P.C.V. = 97.63 C.S.S. = 318755.060

R.S.S. = 311206.190

@ t-value is greater than unity

EQUATION 6 Wheat-irrigated - Nasik(District), Bombay

$$Y = -50.17271 - 1.10708\ X_1 + 3.93515\ X_2\ @ + 2.33717\ X_3 - 0.4747\ X_1^2\ @ - 0.03622\ X_2^2\ * - 0.01828\ X_3^2 + 0.07491\ X_1 X_2\ ** + 0.02045\ X_1 X_3 - 0.03351\ X_2 X_3$$

(3.52068) (2.05042) (4.28604) (0.03194) (0.01687) (0.03283) (0.04047) (0.08764) (0.06044)

N = 32 R^2 = 0.53552 P.C.V. = 53.55 C.S.S. = 231152.350 R.S.S. = 123785.880

EQUATION 7 Wheat-irrigated - Ahmed nagar (District) Bombay

$$Y = -7.97195 - 3.74327\ X_1 + 4.17782\ X_2 + 5.86423\ X_3\ @ + 0.05340\ X_1^2 - 0.00504\ X_2^2 - 0.06270\ X_3^2 - 0.03583\ X_1 X_2 + 0.02572\ X_1 X_3\ @ - 0.04992\ X_2 X_3$$

(6.58593) (4.22894) (5.58429) (0.07380) (0.01950) (0.06551) (0.06860) (0.13680) (0.07747)

N = 35 R^2 = 019466 P.C.V. = 19.47 C.S.S. = 195704.460 R.S.S. = 38096.561

@ t-value is greater than unity

EQUATION 8 Farm Business - Meerut (District), U.P.

$$Y = -104.20189 + 2.14562\ X_1 + 8.50937\ X_2\ @ +$$
$$(2.33422) \quad (6.00095)$$
$$3.55663\ X_3 + 4.34508\ X_4 + 0.41637\ X_5 +$$
$$(9.57512) \quad (1.55879) \quad (0.62155)$$
$$0.00561\ X_1^2 + 0.00227\ X_2^2 - 0.17554\ X_3^2 -$$
$$(0.01276) \quad (0.12440) \quad (0.25762)$$
$$0.07760\ Y_1\ X_2 @ + 0.0686\ X_1\ X_3\ @ - 0.0718\ X_2\ X_3$$
$$(0.06316) \quad (0.12449) \quad (0.34110)$$

N = 100 R^2 = 4 0.44454 P.C.V. = 45.45 C.S.S. = 1461912.700
R.S.S. = 649878.660

EQUATION 9 Farm Business - Muzaffarnagar (District) U.P.

$$Y = 11.06445 + 0.47349\ X_1 + 13.07280\ X_2 -$$
$$(7.82240) \quad (20.22915)$$
$$5.24119\ X_3 + 4.21011\ X_4 + 1.34546\ X_5\ @ -$$
$$(17.15167) \quad (5.15739) \quad (0.99046)$$
$$0.01936\ X_1^2 - 0.02975\ X_2^2 + 0.05080\ X_3^2 -$$
$$(0.06342) \quad (0.33271) \quad (0.14389)$$
$$0.00535\ X_1\ X_2 + 0.17133\ X_1\ X_3 - 0.38185\ X_2\ X_3\ @$$
$$(0.38763) \quad (0.33066) \quad (1.39074)$$

N = 96 R^2 = 0.11128 P.C.V. = 11.13 C.S.S. = 7204517.000
R.S.S. = 801748.270

@ t-value is greater than unity

EQUATION 10 Sugarcane (planted) - Meerut (District), U.P.

$$Y = 143.86956 - 0.23843\ X_1 + 5.61602\ X_2 + 294378\ X_3 + 2.30626\ X_4\ * + 0.02617\ X_1^2\ * + 0.03714\ X_2^2 + 0.31467\ X_3^2 - 0.05892\ X_1 X_2\ @ - 0.03325\ X_1 X_3 - 0.36406\ X_2 X_3$$

(2.28551) (7.78566) (18.06294) (0.58817) (0.01077) (0.08865) (0.55866) (0.05860) (0.16524) (0.52416)

N = 87 $R^2 = 0.62937$ P.C.V. = 62.94

C.S.S. = 6013160.000 R.S.S. = 3784474.200

EQUATION 11 Sugarcane (planted) - Muzaffarnagar, (District), U.P.

$$Y = 58.11675 + 5.98651\ X_1\ * - 0.67689\ X_2 - 2.74660\ X_3 + 2.28742\ X_4\ ** - 0.00687\ X_1^2\ @ + 0.19616\ X_2^2 + 0.098455\ X_3^2\ @ - 0.05358\ X_1 X_2 - 0.07199\ X_1 X_3 + 0.26603\ X_2 X_3$$

(2.64117) (16.01461) (12.04753) (1.18915) (0.00423) (0.39853) (0.09430) (0.09701) (0.10458) (0.60105)

N = 78 $R^2 = 0.40915$ P.C.V. = 40.92

C.S.S. = 3796378.000

R.S.S. = 1553000.120

@ t-value is greater than unity

EQUATION 12 Sugarcane (ratoon) - Meerut (District), U.P.

$$Y = 411.70718 - 2.67689\ X_1 - 5.12405\ X_2 - 9.53081\ X_3 + 0.77986\ X_4 + 0.00690 X_1^2 - 0.23973\ X_2^2\ @ + 0.00523\ X_3^2 + 0.23350\ X_1 X_2\ ** + 0.23090\ X_1 X_3\ @ - 0.25501\ X_2 X_3\ @$$

(4.99294) (9.50546) (15.39499) (0.95313) (0.02911) (0.20609) (0.13715) (0.13445) (0.22668) (0.51321)

N = 91 R^2 = 0.13662 P.C.V. = 13.66 C.S.S. = 2681950.000 R.S.S. = 366399.840

EQUATION 13 Sugarcane (ratoon) - Muzaffarnagar (District), U.P.

$$Y = 158.74984 + 4.08011\ X_1\ ** + 3.79035\ X_2 - 0.46872\ X_3\ * + 0.60929\ X_4 - 0.02238\ X_1^2\ ** - 0.00626\ X_2^2 + 0.03027\ X_3^2 + 0.11309\ X_1 X_2\ @ + 0.08133\ X_1 X_3 - 0.72461\ X_2 X_3$$

(2.53738) (11.36913) (8.65653) (0.85052) (0.012300) (0.22082) (0.10696) (0.09899) (0.11587) (0.51206)

N = 85 R^2 = 0.41019 P.C.V. = 41.02 C.S.S. = 3358521.000 R.S.S. = 1377625.600

@ t-value is greater than unity

EQUATION 14 — Wheat-irrigated - Muzaffarnagar (District), U.P.

$$Y = -70.14285 + 6.90253\ X_1\ @ + 8.78612\ X_2\ @ +$$
$$(4.17216) \qquad (8.12709)$$
$$7.04576\ X_3 - 0.04072\ X_1^2 + 0.00893 X_2^2\ * - 0.07360\ X_3^2 -$$
$$(8.39238) \quad (0.05578) \quad (0.05081) \quad (0.16449)$$
$$0.12856\ X_1 X_2\ @ + 0.03799\ X_1 X_3 - 0.17970\ X_2 X_3$$
$$(0.12713) \qquad (0.13526) \qquad (0.28001)$$

N = 53 R^2 = 0.27152 P.C.V. = 27.15 C.S.S. = 401556.900
R.S.S. = 109030.640

EQUATION 15 — Farm Business - Hoogly (District), West Bengal

$$Y = 2351.28500 + 0.01621\ X_1 - 2.01313\ X_2 -$$
$$(2.28951) \quad (5.69066)$$
$$278.57600\ X_3\ * - 1.98438\ X_4 - 0.00130\ X_1^2 -$$
$$(240.44690) \quad (5.54052) \quad (0.00150)$$
$$0.01721\ X_2^2 + 13.80758\ X_3^2\ * + 0.00945\ X_1 X_2\ @ -$$
$$(0.01911) \quad (3.78688) \quad (0.00778)$$
$$0.03410\ X_1 X_3 + 1.66707\ X_2 X_3\ @$$
$$(0.43353) \qquad (1.36213)$$

N = 75 R^2 = 0.30051 P.C.V. = 30.05 C.S.S.= 145258930.000
R.S.S.= 43651483.000

@ t-value is greater than unity

EQUATION 16 Farm Business - 24 Parganas (District), West Bengal

$$Y = 872.19790 + 2.23160\ X_1 - 2.29967\ X_2\ @ -$$
$$(0.91116) \quad (1.52851)$$
$$351.04318\ X_3\ @ + 0.08384\ X_4 - 0.00074\ X_1^2\ ** -$$
$$(234.58366) \quad (6.86919) \quad (0.00042)$$
$$0.00250\ X_2^2\ @ + 31.32721\ X_3^2\ * + 0.00240\ X_1 X_2\ @ + -$$
$$(0.00186) \quad (14.11482) \quad (0.00156)$$
$$0.54450\ X_1\ X_3\ ** + 0.66151\ X_2\ X_3\ @$$
$$(0.33915) \quad (0.53329)$$

N = 98 R^2 = 0.37820 P.C.V. = 37.82 C.S.S. = 125354830.000
R.S.S. = 47408707.000

EQUATION 17 Aman-Paddy - Hoogly (District), West Bengal

$$Y = 21.88400 + 0.23011\ X_1 + 0.52354\ X_2 +$$
$$(0.30117) \quad (0.73230)$$
$$7.69346\ X_3 + 0.00013\ X_1^2 - 0.00036\ X_2^2 -$$
$$(21.07442) \quad (0.00022) \quad (0.00163)$$
$$0.12757\ X_3^2 - 0.00088\ X_1\ X_2 - 0.015226\ X_1\ X_3 +$$
$$(0.36428) \quad (0.00108) \quad (0.03670)$$
$$0.00845\ X_2\ X_3$$
$$(0.12870)$$

N = 69 R^2 = 0.16333 P.C.V. = 16.33 C.S.S. = 631870.700
R.S.S. = 103200.820

@ t-value is greater than unity

EQUATION 18 Aus-Paddy - Hoogly (District), West Bengal

$$Y = 47.37352 - 0.03003\ X_1 + 7\ 0.71262\ X_2 + 18.38112\ X_3 + 1.57041\ X_4 ** + 0.00033\ X_1^2\ @ + 0.00302\ X_2^2\ * - 0.54511\ X_3^2 - 0.00234\ X_1\ X_2\ ** - 0.01457\ X_1\ X_3 - 0.06307\ X_2\ X_3$$

(0.19930) (0.86385) (26.00929) (0.74353) (0.00021) (0.00106) (1.00893) (0.00125) (0.02784) (0.04785)

N = 18 R^2 = 0.87964 P.C.V. = 87.96 C.S.S. = 42955.340 R.S.S. = 37785.056

EQUATION 19 Aus-Paddy - 24 Parganas (District), West Bengal

$$Y = -37.63915 - 0.29526\ X_1 + 2.64653\ X_2\ * + 7.42940\ X_3 - 7.10770\ X_4\ * + 0.00065\ X_1^2\ @ - 0.00338\ X_2^2 + 1.64262\ X_3^2 - 0.00197\ X_1\ X_2 + 0.01146\ X_1\ X_3 - 0.16894\ X_2\ X_3\ @$$

(0.30941) (1.05918) (38.97047) (3.72344) (0.00042) (0.00410) (2.56525) (0.00255) (0.02713) (0.12267)

N = 19 R^2 = 0.78863 P.C.V. = 78.86 C.S.S. = 46910.160 R.S.S. = 36994.974

@ t-value is greater than unity

EQUATION 20 Jute- Hoogly (District), West Bengal

$$Y = 335.84103 + 0.11758\ X_1 - 1.27943\ X_2\ @ -$$
$$(0.18150) \quad (0.97609)$$
$$67.51587\ X_3{}^{**} - 2.15224\ X_4\ @ - 0.00013\ X_1^2\ @ +$$
$$(28.12213) \quad (1.34146) \quad (0.00008)$$
$$0.00184\ X_2^2 - 0.51837\ X_3^2 + 0.00074\ X_1 X_2\ @ +$$
$$(0.00255) \quad (0.59686) \quad (0.00058)$$
$$0.08755\ X_1 X_3\ * + 0.16123\ X_2 X_3\ @$$
$$(0.02982) \quad (0.14000)$$

N = 46 R^2=0.61933 P.C.V. = 61.93 C.S.S. = 1299470.700
R.S.S. = 804797.690

EQUATION 21 Jute - 24 Parganas (District), West Bengal

$$Y = 128.25760 + 0.26253\ X_1\ ** - 0.75379\ X_2\ @ +$$
$$(0.14206) \quad (0.57430)$$
$$87.53274\ X_3\ ** - 1.20985 X_4{}^{**} - 0.00012\ X_1^2 +$$
$$(44.73977) \quad (0.65312) \quad (0.00007)$$
$$0.00002\ X_2^2 - 4.87805\ X_3^2\ @ + 0.00081\ X_1 X_2\ @ -$$
$$(0.00093) \quad (4.33390) \quad (0.00067)$$
$$0.00471\ X_1 X_3\ @ - 0.10846\ X_2 X_3\ @$$
$$(0.03556) \quad (0.08816)$$

N = 40 R^2 = 0.48022 P.C.V. = 48.02 C.S.S. = 675106.700
R.S.S. = 324196.550

@ t-value is greater than unity

EQUATION 22 Farm Business - Coimbatore (District), Madras

$$Y = 47.18049 - 1.03508\ X_1\ @ + 4.36700\ X_2\ * - 5.02955\ X_3\ ** + 1.44200\ X_4\ * - 0.03343\ X_5 + 0.00766\ X_1^2\ ** - 0.03758\ X_2^2\ * + 0.03748\ X_3^2\ @ - 0.00305\ X_1 X_2 + 0.09707\ X_1 X_3\ * + 0.04237\ X_2 X_3\ @$$

(0.87796) (0.97963) (2.56389) (0.48345) (0.32308) (0.00377) (0.01136) (0.03620) (0.01034) (0.04789) (0.02749)

N = 97 R^2 = 0.67410 P.C.V. = 67.41 C.S.S. = 1134923.600 R.S.S. = 765039.680

EQUATION 23 Farm Business - Salem (District), Madras

$$Y = 173.44288 + 2.29869\ X_1\ @ - 2.42484\ X_2\ @ - 41.53413\ X_3\ * + 2.20517\ X_4\ * - 0.01967\ X_1^2\ @ - 0.00594\ X_2^2 + 1.03716\ X_3^2\ * + 0.02485\ X_1 X_2\ @ + 0.21251\ X_1 X_3 + 0.19548\ X_2 X_3\ @$$

(2.01630) (1.53845) (15.99245) (1.00077) (0.01217) (0.01258) (0.44246) (0.02181) (0.22679) (0.16475)

N = 94 R^2 = 0.30063 P.C.V. = 30.06 C.S.S. = 2657143.200 R.S.S. = 768749.990

@ t-value is greater than unity

EQUATION 24 Paddy-irrigated (Season I) - Salem & Coimbatore (Districts) Madras

$$Y = 11.66368 + 2.43173\ X_1\ @ - 0.20767\ X_2 + 5.06172\ X_3 + 2.37797\ X_4\ * - 0.00085\ X_1^2 + 0.00081\ X_2^2 + 0.15161\ X_3^2 - 0.00310\ X_1 X_2 - 0.19039\ X_1 X_3 + 0.13985\ X_2 X_3$$

(2.13622) (2.34904) (19.42194) (0.54622) (0.00369) (0.00250) (0.39516) (0.00421) (0.20305) (0.22968)

N = 42 R^2 = 0.66446 P.C.V. = 66.45 C.S.S. = 7957675.000 R.S.S. = 5287580.000

EQUATION 25 Paddy-irrigated (Season II) - Coimbatore (District) Madras

$$Y = 348.08772 - 3.03623\ X_1\ ** + 2.85442\ X_2\ ** - 10.99020\ X_3 + 3.45723\ X_4\ ** + 0.00385\ X_1^2\ * + 0.00175\ X_2^2\ ** + 0.12269\ X_3^2 - 0.00509\ X_1 X_2\ * + 0.10546\ X_1 X_3 - 0.08488\ X_2 X_3$$

(1.73114) (1.38896) (20.60321) (1.64681) (0.00061) (0.00088) (0.37909) (0.00113) (0.12673) (0.09483)

N = 21 R^2 = 0.99182 P.C.V. = 99.18 C.S.S. =38946378.000 R.S.S. = 38627755.000

@ t-value is greater than unity

EQUATION 26 Paddy-irrigated (Season II), Salem (District) Madras

$$Y = 548.28610 + 10.38800\ X_1\ @ - 10.53122\ X_2\ ** - 63.35700\ X_3 + 0.74159\ X_4 - 0.02180\ X_1^2 + 0.01158\ X_2^2 + 1.82839\ X_3^2 + 0.00966\ X_1 X_2 ** - 0.46172\ X_1 X_3 + 0.58818\ X_2 X_3$$

(6.88052) (5.55662) (75.72039) (1.00438) (0.02502) (0.02191) (4;03511) (0.04644) (0.95522) (0.73730)

N = 28 R^2 = 0.8821 P.C.V. 88.26 C.S.S. = 4799520700

R.S.S = 4236109.800

EQUATION 27 Jowar-irrigated - Coimbatore (District), Madras

$$Y = 213.10509 - 3.32334\ X_1\ @ + 4.33953\ X_2 - 4.16082\ X_3 - 0.00015\ X_1^2 - 0.03634\ X_2^2 + 0.03838\ X_3^2 + 0.03430\ X_1 X_2 + 0.07691\ X_1 X_3 - 0.12932\ X_2 X_3$$

(3.27507) (4.56415) (14.94870) (0.1546) (0.5346) (0.19108) (0.06624) (0.25341) (0.28102)

N = 29 R^2 = 0.58481 P.C.V = 58.48 C.S.S. = 1767663.700

R.S.S. = 1033747.100

@ t-value is greater than unity

EQUATION 28 — Jowar-irrigated (Season II) - Salem (District) Madras

$$Y = 183.84122 - 2.41101\ X_1 + 3.24855\ X_2 - 27.26336\ X_3 - 1.17393\ X_4\ @ - 0.02265\ X_1^2 - 0.02253\ X_2^2 + 0.96404\ X_3^2 + 0.04965\ X_1 X_2 + 1.25383\ X_1 X_3\ ** - 1.39204\ X_2 X_3\ **$$

(4.04641) (3.66913) (38.64581) (1.20864) (0.03539) (0.03106) (2.08406) (0.06367) (0.53225) (0.79202)

N = 28 R^2 = 0.96761 P.C.V = 96.76 C.S.S. = 6384187.000 R.S.S. = 6177407.000

EQUATION 29 — Cotton-irrigated - Coimbatore (District), Madras

$$Y = -86.28813 + 3.12800\ X_1\ ** + 1.54960\ X_2 + 6.83971\ X_3\ @ - 0.00666\ X_1^2\ @ + 0.00938\ X_2^2 - 0.05269\ X_3^2 + 0.00342\ X_1 X_2 + 0.10771\ X_1 X_3 - 0.37704\ X_2 X_3\ **$$

(1.81816) (2.24345) (5.83914) (0.00578) (0.01465) (0.07801) (0.01731) (0.15610) (0.18935)

N = 36 R^2 = 0.98544 P.C.V. = 98.54 C.S.S. = 32967790.000 R.S.S. = 32487915.000

@ t-value is greater than unity

EQUATION 30 Cotton-irrigated - Salem (District), Madras

$$Y = -56.11287 + 5.46053\ X_1\ ** - 6.78548\ X_2\ * + 36.78534\ X_3\ @ - 0.00372\ X_1^2 + 0.02738\ X_2^2\ * - 2.28388\ X_3^2\ @ - 0.01205\ X_1 X_2\ * - 0.01621\ X_1 X_3 + 0.11410\ X_2 X_3$$

(1.56711) (2.03071) (33.07178) (0.00346) (0.00495) (1.87914) (0.00327) (0.22545) (0.20835)

N = 21 R^2 = 0.97210 P.C.V. = 97.21 C.S.S. = 2 354409.000

R.S.S. = 3445226.000

@ t-value is greater than unity

Note: Figures in parenthesis indicate the Standard Error of the Coefficient above.

APPENDIX II

FIRST TRIAL EQUATIONS OF REGRESSION ANALYSIS

(COBB - DOUGLAS TYPE FUNCTIONS)

EQUATION 1 — Farm Business - Nasik (District), Bombay

$$Y = 1.63113\ X_1^{0.30695@}\ X_2^{0.65877*}\ X_3^{-0.01635}\ X_4^{0.01251}$$

(0.24363) (0.23797) (0.10293) (0.03459)

N = 61 R^2 = 0.77569 C.S.S. = 12.20553 R.S.S. = 1.63113

EQUATION 2 — Farm Business - Ahmednagar (District), Bombay

$$Y = 2.09899\ X_1^{0.84398*}\ X_2^{-0.05303}\ X_3^{0.09177@}\ X_5^{0.03634*}$$

(0.20155) (0.13352) (0.08040) (0.01807)

N = 77 R^2 = 0.51827 C.S.S. = 7.67432 R.S.S. = 2.09898

EQUATION 3 — Jowar-unirrigated - Ahmednagar (District), Bombay

$$Y = 1.08965\ X_1^{1.27907*}\ X_2^{-0.27728@}\ X_3^{0.11222@}$$

(0.19507) (0.21434) (0.09006)

N = 55 R^2 = 0.59897 C.S.S. = 6.66015 R.S.S. = 1.08965

EQUATION 4 — Jowar-irrigated - Ahmednagar (District), Bombay

$$Y = 0.69654\ X_1^{1.51031*}\ X_2^{-0.35226**}\ X_3^{0.15400**}$$

(0.24384) (0.17661) (0.08924)

N = 50 R^2 = 0.55181 C.S.S. = 7.63151 R.S.S. = 4.21116

Note: Notations used in the quadratic functions will be followed for Cobb Douglas Type of Functions also.

EQUATION 5 Wheat-unirrigated - Nasik (District), Bombay

$$Y = 1.05548\, X_1^{0.03250}\, X_2^{1.14080*}\, X_3^{-0.08105}$$

(0.30235) (0.39187) (0.14059)

N = 31 R^2 = 0.59621 C.S.S. = 4.88195 R.S.S.= 2.91068

EQUATION 6 Wheat-irrigated - Nasik (District), Bombay

$$Y = 5.23812\, X_1^{1.25828*}\, X_2^{-0.58054@}\, X_3^{0.019142}$$

(0.32981) (0.31813)(0.09008)

N = 32 R^2 = 0.48773 C.S.S. = 2.00655 R.S.S.= 0.97865

EQUATION 7 Wheat-irrigated - Ahmed nagar (District), Bombay

$$Y = 7.29698\, X_1^{0.31555}\, X_2^{0.19104}\, X_3^{0.22151}$$

(0.31769)(0.24194) (0.12657)

N = 35 R^2 = 0.25396 C.S.S. = 2.58745 R.S.S. = 0.65711

EQUATION 8 Farm Business - Meerut (District), U.P.

$$Y = 21.54063\, X_1^{0.31296*}\, X_2^{0.38203*}\, X_3^{0.02124}\, X_4^{0.03398**}\, X_5^{-0.0269}$$

(0.07941)(0.09436) (0.06816) (0.01728) (0.03993)

N = 100 R^2 = 0.40155 C.S.S. = 3.93252 R.S.S. = 1.57911

EQUATION 9 Farm Business - Muzaffarnagar (District), U.P.

$$Y = 43.31439\, X_1^{0.15739@}\, X_2^{0.35745*}\, X_3^{-0.05830}\, X_4^{0.01953}\, X_5^{0.05520*}$$

(0.14327) (0.14747) (0.06117) (0.02084) (0.03509)

N = 96 R^2 = 0.25923 C.S.S. = 4.80788 R.S.S. = 01.24633

EQUATION 10 Sugarcane-planted - Meerut (District), U.P.

$$Y = 14.69893 X_1^{0.74498*} X_2^{-0.041198} X_3^{-0.02693} X_4^{0.03520@}$$

(0.17326) (0.13968) (0.14928) (0.02232)

N = 87 R^2 = 0.21190 C.S.S.= 9.83935 R.S.S. = 2.08500

EQUATION 12 Sugarcane-ratoon - Meerut (District), U.P.

$$Y = 129.0039 X_1^{0.15332@} X_2^{0.15691*} X_3^{-0.02755} X_4^{0.02351}$$

(0.13147) (0.05519) (0.10364) (0.01464)

N = 91 R^2 = 0.13878 C.S.S. = 5.03244 R.S.S. = 0.69838

EQUATION 13 Sugarcane-ratoon - Muzaffernagar (District), U.P.

$$Y = 3.35687 X_1^{1.05335*} X_2^{-0.03063} X_3^{0.19444@} X_4^{0.04043@}$$

(0.28445) (0.23704) (0.17173) (0.03374)

N = 85 R^2 = 0.25459 C.S.S = 25.01176 R.S.S. = 6.36772

EQUATION 14 Wheat-irrigated - Muzaffernagar (District), U.P.

$$Y = 21.76056 X_1^{0.34508*} X_2^{0.31754*} X_3^{0.06658}$$

(0.16063) (0.15198) (0.08071)

N = 53 R^2 = 0.46642 C.S.S. = 2.66136 R.S.S. = 1.24131

EQUATION 15 Farm Business - Hoogly (District), West Bengal.

$$Y = 2888.41060 X_1^{-0.31415} X_2^{0.03750} X_3^{-1.17907*} X_4^{0.06166@}$$

(0.33547)(0.3566) (0.12647) (0.03889)

N = 75 R^2 = 0.57448 C.S.S. = 36.49994 R.S.S. = 20.96861

EQUATION 16 Farm Business - 24 Parganas (District), West Bengal.

$$Y = 289.68058X_1^{-0.00792}\ X_2^{0.11854}\ X_3^{-01.25803*}\ X_4^{0.01307}$$

(0.16473)(0.12052) (0.07848) (0.02207)

N = 98 R^2 = 0.78288 C.S.S. = 37.78476 R.S.S. = 29.58096

EQUATION 17 Aman-Paddy - Hoogly (District), West Bengal.

$$Y = 15.99869X_1^{0.38179*}\ X_2^{-0.02874}\ X_3^{0.05687}$$

(0.14209) (0.04773) (0.05909)

N = 69 R^2 = 0.11260 C.S.S. = 3.13116 R.S.S. = 0.35256

EQUATION 18 Aus-Paddy - Hoogly (District), West Bengal.

$$Y = 117.49922X_1^{-0.04048}\ X_2^{0.11213*}\ X_3^{-0.15971}\ X_4^{0.02842}$$

(0.17592)(0.04580) (0.11811) (0.03181)

N = 18 R^2 = 0.35523 C.S.S. = 0.43083 R.S.S. = 0.15304

EQUATION 19 Aus-Paddy - 24 Parganas (District), West Bengal.

$$Y = 15.22826X_1^{0.37340@}\ X_2^{-0.05279}\ X_3^{-0.01772}\ X_4^{-0.02599}$$

(0.28243)(0.36195) (0.13890) (0.03806)

N = 19 R^2 = 0.21030 C.S.S = 0.59325 R.S.S. = 0.12476

EQUATION 20 Jute - Hoogly (District), West Bengal.

$$Y = 5.11132X_1^{0.46699*}\ X_2^{0.16817@}\ X_3^{0.18484*}\ X_4^{-0.02571@}$$

(0.15917) (0.14251) (0.06733) (0.02320)

N = 46 R^2 = 0.35177 C.S.S. = 2.92642 R.S.S. = 01.102943

EQUATION21 Jute - 24 Parganas (District), West Bengal)

$$Y = 13.87264X_1^{0.49592*} \quad X_2^{-0.04775} \quad X_3^{0.09489@} \quad X_4^{-0.03007@}$$

(0.12632) (0.09141) (0.05820) (0.01607)

N = 40 R^2 = 0.35903 C.S.S. = 1.05218 R.S.S. = 0.37776

EQUATION 11 Sugarcane-planted - Muzaffarnagar (District), U.P.

$$Y = 41.65798X_1^{0.31114*} \quad X_2^{0.40858*} \quad X_3^{-0.05407} \quad X_4^{-0.00593}$$

(0.11950) (0.14610) (0.08612) (0.01789)

N = 78 R^2 = 0.25292 C.S.S. = 5.33482 R.S.S. = 1.34926

EQUATION 22 Farm Business - Coimbatore (District), Madras

$$Y = 3.33490X_1^{0.68154*} \quad X_2^{0.22957**} \quad X_3^{-0.00456} \quad X_4^{-0.04893@} \quad X_5^{0.01430}$$

(0.14980) (0.13983) (0.10056) (0.03501) (0.02736)

N = 97 R^2 = 0.55277 C.S.S. = 22.19436 R.S.S = 12.26845

EQUATION 23 Farm Business - Salem (District), Madras

$$Y = 1.94352X_1^{01.00582*} \quad X_2^{-0.05146} \quad X_3^{-0.03867} \quad X_4^{0.04740}$$

(0.19829) (0.14203) (0.13866) (0.05959)

N = 94 R^2 = 0.39909 C.S.S. = 26.41405 R.S.S. = 10.54152

EQUATION 24 Paddy-Irrigated (Season I) - Salem & Coimbatore (Districts) Madras

$$Y = 12.85158X_1^{0.43981*} \quad X_2^{0.00213} \quad X_3^{-0.03372} \quad X_4^{0.27715*}$$

(0.17628) (0.14950) (0.11417) (0.11750)

N = 42 R^2 = 0.56863 C.S.S. = 6.75181 R.S.S. = 3.83925

EQUATION 25 Paddy-irrigated (Season II), Coimbatore (District), Madras

$$Y = 21.57096 X_1^{0.99821*} \; X_2^{-0.36312**} \; X_3^{-0.18465@} \; X_4^{0.00550}$$

(0.26111)(0.19917) (0.14718) (0.03377)

N = 21 R^2 = 0.79393 C.S.S. = 3.61740 R.S.S = 2.87197

EQUATION 26 Paddy-irrigated (Season II) - Salem (District), Madras

$$Y = 42.55602 X_1^{0.53899@} \; X_2^{-0.04095@} \; X_3^{-0.85251@} \; X_4^{0.01953}$$

(0.41185)(0.36954) (0.26082) (0.07172)

N = 28 R^2 = 0.53371 C.S.S. = 03.90261 R.S.S. 2.08285

EQUATION 27 Jowar-irrigated (Season II) - Coimbatore (District), Madras

$$Y = 92.79090 X_1^{0.14294} \; X_2^{0.11150} \; X_3^{-0.29121**}$$

(0.32333) (0.29939) (0.18762)

N = 29 R^2 = 0.22368 C.S.S. = 4.54819 R.S.S. = 1.01751

EQUATION 28 Jowar-irrigated (Season II) - Salem (District), Madras

$$Y = 2.36844 X_1^{0.76518*} \; X_2^{0.13230} \; X_3^{0.15363} \; X_4^{-0.05486@}$$

(0.28495) (0.21460) (0.32262) (0.04238)

N = 28 R^2 = 0.60600 C.S.S. = 6.58419 R.S.S. = 3.98989

EQUATION 29 Cotton-irrigated - Coimbatore (District), Madras

$$Y = 7.03791 X_1^{0.44623*} \; X_2^{0.38807**} \; X_3^{-0.06538}$$

(0.23220) (0.20651) (0.12259)

N = 36 R^2 = 0.80316 C.S.S. = 12.14606 R.S.S. = 9.75527

EQUATION 30 Cotton-irrigated - Salem (District), Madras.

$$Y = 23.92982 X_1^{0.67950*} X_2^{-0.03532} X_3^{-0.50367**}$$

(0.19604)(0.08741) (0.24373)

N = 21 R^2 = 0.60455 C.S.S. = 4.40086 R.S.S. = 2.66055

APPENDIX III

SECOND TRIAL EQUATIONS OF REGRESSION ANALYSIS

(QUADRATIC FUNCTIONS)

EQUATION [3] Jowar-unirrigated - Ahmed nagar (District), Bombay

$$Y = 2.17976 + \underset{(0.70101)}{1.56469\ X_1}{}^{*} - \underset{(0.51874)}{0.37965\ X_3} - 0.00105\ X_1^2 + 0.00314\ X_3^2 + 0.02339\ X_1 X_3 @$$

$$\underset{(0.00737)}{\quad} \qquad \underset{(0.00572)}{\quad} \qquad \underset{(0.01463)}{\quad}$$

$N = 55 \quad R^2 = 0.70702 \quad C.S.S. = 35502.873 \quad R.S.S. = 25101.400$

EQUATION [4] Jowar-irrigated - Ahmed nagar (District), Bombay

$$Y = -41.84712 + \underset{(1.77000)}{2.79184 X_1}@ + \underset{(2.33777)}{1.55085\ X_3} - 0.00201\ X_1^2 + 0.00933\ X_3^2 - 0.01394\ X_1 X_3$$

$$\underset{(0.01352)}{\quad} \qquad \underset{(0.02592)}{\quad} \qquad \underset{(0.03960)}{\quad}$$

$N = 50 \quad R^2 = 0.51322 \quad C.S.S. = 281201.310 \quad R.S.S. = 144319.400$

EQUATION [6] Wheat-irrigated - Nasik (District), Bombay

$$Y = -40.52479 + \underset{(1.62960)}{2.45802\ X_2} @ + \underset{(3.89621)}{2.25449\ X_3} - 0.00506\ X_2^2 - 0.01869\ X_3^2 - 0.01061\ X_2 X_3$$

$$\underset{(0.00527)}{\quad} \qquad \underset{(0.03255)}{\quad} \qquad \underset{(0.02560)}{\quad}$$

$N = 32 \quad R^2 = 0.37613 \quad C.S.S. = 231152.350 \quad R.S.S. = 86942.670$

EQUATION 11 Sugarcane- planted - Muzaffernagar (District), U.P.

$$Y = 110.69343 + 6.00976\ X_1\ ^{*} + 0.42501\ X_3 - 0.00807\ X_1^2\ ^{**} + 0.11311\ X_3^2\ ^{@} - 0.07481\ X_1\ X_3\ ^{*}$$

(1.27793) (9.99925) (0.00432) (0.9446) (0.09687)

N = 78 R^2 = 0.33253 C.S.S. = 3796378.000 R.S.S.= 1262424.500

EQUATION 13 Sugarcane-ratoon - Muzaffernagar (District), U.P.

$$Y = 139.35695 + 6.18176\ X_1\ ^{*} - 1.68419\ X_3 - 0.01434\ X_1^2\ ^{@} + 0.04334\ X_3^2 - 0.03068\ X_1\ X_3$$

(2.11112) (8.31388) (0.00928) (0.10340) (0.08984)

N = 85 R^2 = 0.37632 C.S.S. = 3356521.000 R.S.S. = 1260512.100

EQUATION 14 Wheat-irrigated - Muzaffernagar (District), U.P.

$$Y = -4.78794 + 9.60315\ X_1\ ^{*} + 3.50993\ X_3 - 0.08737\ X_1^2\ ^{*} - 0.00833\ X_3^2 - 0.02057\ X_1\ X_3$$

(2.99863) (6.67633) (0.03314) (0.15147) (0.09325)

N = 53 R^2 = 0.22975 C.S.S. = 401556.900 R.S.S. = 92256.871

EQUATION 16 Farm Business - 24 Parganas (District), West Bengal

$$Y = 1109.98830 + 1.00621\ X_1\ @ - 438.79320\ X_3{}^{*} - 0.00015\ X_1^2\ @ + 35.87730\ X_3^2{}^{*} - 0.22024\ X_1\ X_3$$

(0.62365) (218.76716) (0.00009) (13.64492) (0.26832)

$N = 98$ $R^2 = 0.33762$ C.S.S. = 125354830.000

R.S.S. = 42323496.000

EQUATION19 Aus-paddy - 24 Parganas (District), West Bengal.

$$Y = - 123.16549 + 2.73224\ X_2\ * + 15.09485\ X_3{}^{*} - 0.00569\ X_2^2\ * + 2.52567\ X_3^2\ @ - 0.23196\ X_2\ X_3{}^{@}$$

(1.21934) (35.33227) (0.00250) (2.46338) (0.14012)

$N = 19$ $R^2 = 0.45281$ C.S.S. = 46910.160

R.S.S. = 21241.206

EQUATION 20 Jute - Hoogly (District), West Bengal

$$Y = 304.49267 - 0.055478\ Y_1 - 46.70486\ X_3\ @ + 0.00002\ X_1^2 + 0.02042\ X_3^2 + 0.08168\ X_1\ X_3\ *$$

(0.19698) (31.33705) (0.00005) (0.42603) (0.03144)

$N = 46$ R^2 0.40197 C.S.S. = 1299470.700

R.S.S. = 522344.120

EQUATION 21 Jute - 24 Parganas (District), West Bengal

$$Y = 109.21598 + 0.22824\ X_1\ @ + 38.59263\ X_3 - \underset{(0.13181)}{} \underset{(43.66973)}{}$$

$$0.00003\ X_1^2\ @ - 4.34477\ X_3^2\ @ - 0.005533\ X_1\ X_3$$
$$(0.00002) \quad (3.97164) \quad (0.03279$$

N = 40 $R^2 = 0.29357$ C.S.S. = 676106.700

R.S.S. = 198192.440

EQUATION 22 Farm Business - Coimbatore (District), Madras.

$$Y = 18.98311 + 4.97160\ X_2 + 1.20498\ X_3 - \underset{(0.80587)}{} \underset{(2.18727)}{}$$

$$0.02576\ X_2^2\ * + 0.01582\ X_3^2 + 0.00341\ X_2\ X_3$$
$$(0.00671) \quad (0.04117) \quad (0.01379)$$

N = 97 $R^2 = 0.41392$ C.S.S. = 1134922.600

R.S.S. = 469772.130

EQUATION 23 Farm Business - Salem (District), Madras

$$Y = 183.29856 + 0.49963\ X_1\ * - 04.04634\ X_3\ * - \underset{(1.41934)}{} \underset{(15.24974)}{}$$

$$0.00247\ X_1^2 + 0.93780\ X_3^2\ * + 0.43588\ X_1\ X_3\ *$$
$$(0.00494) \quad (0.42568) \quad (0.19720)$$

N = 94 $R^2 = 0.23117$ C.S.S. = 2557143.200

R.S.S. = 591130.650

EQUATION 24 Paddy-irrigated (Season I) - Salem (District), Madras

$$Y = 52.97178 + 3.12053\ X_1{}^{*} + 1.79067\ X_3 - 0.00208\ X_1^2 + 0.16932\ X_3^2 - 0.09117\ X_1 X_3$$

(0.42433) (23.74672) (0.00218) (0.46741) (0.10348)

N = 42 R^2 = 0.39908 C.S.S. = 7957675.000 R.S.S. = 3175778.000

EQUATION 26 Paddy-irrigated (Season II) - Salem (District), Madras

$$Y = 380.36521 + 0.89257\ X_1 - 82.93820\ X_3 - 0.00040\ X_1^2 + 3.54488\ X_3^2 + 0.24641\ X_1 X_3\ @$$

(2.04067) (118.34737) (0.00170) (6.32244) (0.23799)

N = 28 R^2 = 0.55745 C.S.S. = 4799520.700 R.S.S. = 2675500.800

EQUATION 27 Jowar-irrigated - Coimbatore (District), Madras

$$Y = 213.10509 - 3.32334\ X_1\ @ + 4.33953\ X_2 - 4.16082\ X_3 - 0.00015\ X_1^2 - 0.03634\ X_2^2 + 0.03838\ X_3^2 + 0.03430\ X_1 X_2 + 0.07691\ X_1 X_3 - 0.12932\ X_2 X_3$$

(3.27507) (4.56414) (14.94870) (0.01546) (0.05346) (0.19108) (0.06624) (0.25341) (0.28102)

N = 29 R^2 = 0.58481 C.S.S. = 1767663.700 R.S.S. = 1033747.100

EQUATION 28 Jowar-irrigated (Season II) - Salem (District), Madras

$$Y = 207.51707 - \underset{(1.30617)}{1.06102}\ X_2 - \underset{(43.67168)}{30.74810}\ X_3 + \underset{(0.00127)}{0.00618}\ X_2^2\ * + \underset{(2.37384)}{1.46321}\ X_3^2 + \underset{(0.27036)}{0.31491}\ X_2\ X_3\ @$$

N = 28 $R^2 = 0.94492$ C.S.S. = 6384187.000

R.S.S. = 6032523.900

EQUATION 29 Cotton-irrigated - Coimbatore (District), Madras

$$Y = 16.96154 + \underset{(0.61145)}{2.46488}\ X_1\ * + \underset{(7.54216)}{0.62841}\ X_3 + \underset{(0.00027)}{0.00024}\ X_1^2 - \underset{(0.10892)}{0.00159}\ X_3^2 - \underset{(0.03060)}{0.02568}\ X_1\ X_3$$

N = 36 $R^2 = 0.96537$ C.S.S. = 32967790.000

R.S.S. = 31826148.000

EQUATION 30 Cotton-irrigated - Salem (District), Madras

$$Y = 763.57180 - \underset{(3.32605)}{0.63909}\ X_1 - \underset{(123.35847)}{125.73452}\ X_3\ @ + \underset{(0.00769)}{0.00251}\ X_1^2 + \underset{(7.31380)}{05.23901}\ X_3^2 + \underset{(0.43076)}{0.03704}\ X_1\ X_3$$

N = 21 $R^2 = 0.27776$ C.S.S. = 354409.000

R.S.S. = 984421.380

APPENDIX IV

SECOND TRIAL EQUATIONS OF REGRESSION ANALYSIS

(COBB - DOUCLAS TYPE FUNCTIONS)

EQUATION 1 — **Farm Business - Nasik (District), Bombay**

$$Y = 1.47384\ X_1^{0.31511@}\ X_2^{0.68272*}$$

$$(0.22419) \qquad (0.22287)$$

$N = 61$ $\quad R^2 = 0.77515$ $\quad C.S.S. = 12.20553$ $\quad R.S.S. = 9.46111$

EQUATION 2 — **Farm Business - Ahmed nagar (District) Bombay**

$$Y = 3.35178\ X_1^{0.69593*}\ X_5^{0.03896*}$$

$$(0.02208) \qquad (0.00396)$$

$N = 77$ $\quad R^2 = 0.50941$ $\quad C.S.S. = 7.67432$ $\quad R.S.S. = 3.90947$

EQUATION 3 — **Jowar-unirrigated - Ahmed nagar (District) Bombay**

$$Y = 0.88984\ X_1^{1.09957*}\ X_3^{0.09659@}$$

$$(0.13800) \qquad (0.08982)$$

$N = 55$ $\quad R^2 = 0.58581$ $\quad C.S.S. = 6.66015$ $\quad R.S.S. = 3.90160$

EQUATION 4 — **Jowar-irrigated - Ahmed nagar (District) Bombay**

$$Y = 0.67853\ X_1^{1.15428*}\ X_3^{0.18823*}$$

$$(0.16497) \qquad (0.09000)$$

$N = 50$ $\quad R^2 = 0.51522$ $\quad C.S.S. = 7.63151$ $\quad R.S.S. = 3.93191$

EQUATION 5 — **Wheat-unirrigated - Nasik (District), Bombay**

$$Y = 3.38120\ X_1^{0.80358*}\ X_3^{-0.00459}$$

$$(0.16410) \qquad (0.15546)$$

$N = 31$ $\quad R^2 = 0.46947$ $\quad C.S.S. = 4.88195$ $\quad R.S.S. = 2.29195$

EQUATION 6 Wheat-irrigated - Nasik (District) Bombay

$$Y = 5.73150\ X_1^{-0.58918*}\ X_2^{1.25787*}$$

(0.05846) (0.06111)

N = 32 R^2 = 0.48690 C.S.S. = 2.00655 R.S.S. = 0.97698

EQUATION 7 Wheat-irrigated - Ahmed nagar (District) Bombay

$$Y = 11.65763\ X_2^{0.39106*}\ X_3^{0.19866@}$$

(0.13408) (0.12444)

N = 35 R^2 = 0.23023 C.S.S. = 2.58745 R.S.S. = 0.59567

EQUATION 8 Farm Business - Meerut (District) U.P.

$$Y = 18.80351\ X_1^{0.31186*}\ X_2^{0.39059*}\ X_3^{0.01876}\ X_4^{0.03481*}$$

(0.07916) (0.09324) (0.06786) (0.01719)

N = 100 R^2 = 0.39865 C.S.S. = 3.93252 R.S.S. = 1.56769

EQUATION 10 Sugarcane-planted - Muzaffernagar (District) U.P.

$$Y = 42.94526\ X_1^{0.30829*}\ X_2^{0.40496*}\ X_3^{-0.06019}$$

(0.11847) (0.14481) (0.08362)

N = 78 R^2 = 0.25179 C.S.S. = 5.33482 R.S.S. = 1.34326

EQUATION 16 Farm Business - 24 Pargenas (District) W. Bengal

$$Y = 219.03500\ X_2^{0.13553*}\ X_3^{-1.25290*}$$

(0.02540) (0.02121)

N = 98 R^2 = 0.78194 C.S.S. = 37.78476 R.S.S. = 28.68380

EQUATION 17 Amen-paddy - Hoogly (District) West Bengal

$$Y = 15.47126\ X_1^{0.36391*}\ X_3^{0.05380}$$

(0.13851) (0.05877)

N = 69 R^2 = 0.10730 C.S.S. = 3.13116 R.S.S. = 0.33597

EQUATION 20 Jute - Hoogly (District) West Bengal

$$Y = 44.41521\ X_1^{0.46680*}\ X_2^{0.20184@}\ X_3^{0.15622*}$$

(0.15960) (0.13961) (0.06235)

N = 46 R^2 = 0.33236 C.S.S. = 2.92642 R.S.S. = 0.97262

EQUATION 21 Jute - 24 Parganas (District) West Bengal

$$Y = 22.09900\ X_1^{0.41148*}\ X_2^{-0.02457*}$$

(0.01728) (0.01077)

N = 40 R^2 = 0.29465 C.S.S. = 1.05218 R.S.S. = 0.31003

$$Y = 15.56750\ X_1^{0.40628*}\ X_3^{0.05126*}$$

(0.02540) (0.02121)

N = 40 R^2 = 0.28940 C.S.S. = 1.05218 R.S.S. = 0.30450

$$Y = 15.87610\ X_2^{0.13049*}\ X_3^{0.01226@}$$

(0.01476) (0.01031)

N = 40 R^2 = 0.05781 C.S.S. = 1.05218 R.S.S. = 0.06083

EQUATION 22 Farm Business - Coimbatore (District) Madras

$$Y = 3.82359\ X_1^{0.66187*}\ X_2^{0.19148}$$

(004408) (0.04027)

N = 97 R^2 = 0.54243 C.S.S. = 22.19436 R.S.S. = 12.03891

EQUATION 23 Farm Business - Salem (District), Madras

$$Y = 1.73196\ X_1^{0.98221*}\ X_3^{0.03376}$$

(0.14500) (0.05146)

N = 94 R^2 = 0.39757 C.S.S. = 26.41405 R.S.S. = 10.50136

EQUATION 24 Paddy-irrigated - Salem and Coimbatore (Districts) Madras

$$Y = 7.45685\ X_1^{0.67173*}\ X_4^{0.12011@}$$

(0.10598) (0.8668)

N = 42 R^2 = 0.51681 C.S.S. = 6.75181 R.S.S. = 3.48937

EQUATION 25 Paddy-irrigated (Season III) - Coimbatore (District) Madras

$$Y = 38.07612\ X_1^{0.55634*}\ X_3^{-0.178449}$$

(0.03847) (0.15364)

N = 21 R^2 = 0.74461 C.S.S. = 3.61740 R.S.S.= 2.69357

EQUATION 26 Paddy-irrigated (Season II) - Salem (District) Madras

$$Y = 42.23500\ X_1^{0.51133*}\ X_3^{-0.35249*}$$

(0.03288) (0.06652)

N = 28 R^2 = 0.53159 C.S.S. = 3.90261 R.S.S. = 2.07458

EQUATION 27 Jowar-irrigated (Season III) - Salem (District) Madras

$$Y = 4.31285\ X_1^{0.73581*}\ X_2^{0.08853}$$

(0.26980) (0.21089)

N = 28 R^2 = 0.57411 C.S.S. = 6.58419 R.S.S. = 3.78003

EQUATION 28 Cotton-irrigated - Coimbatore (District), Madras

$$Y = 5.91939\ X_1^{0.44883*}\ X_2^{0.39233*}$$

(0.06446) (0.05720)

N = 36 R^2 = 0.79258 C.S.S. = 12.14606 R.S.S. = 9.62673

EQUATION 29 Cotton-irrigated - Salem (District), Madras

$$Y = 2.28396\ X_1^{1.13340*}\ X_3^{-0.35300*}$$

(0.01705) (0.00790)

N = 21 R^2 = 0.88065 C.S.S. = 4.40086 R.S.S. = 3.87570

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