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INPUT-OUTPUT RELATIONS IN AGRICULTURE

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I

INPUT-OUTPUT ECONOMICS[1]

In recent years, with the development of macro-economic analysis,the utility of input-output approach as a significant tool of economic analysis has attracted considerable attention. In a number of countries construction of input-output matrices is known to have been attempted. But in underdeveloped countries, the subject has not attracted sufficient notice so far. One may, therefore, be excused if an attempt is made at the outset to describe input-output analysis and its limitations. Input-output analysis stems from the fact of common observation that all sectors in an economy are inter-related. Needs of one sector are furnished by other sectors. If the first sector is to expand its activities, it could do so only by an expansion *pari passu* in the other sectors, supposing of course that its needs were not made good by drawing down stocks or by imports. Input-output work is a technique which is devised to lay bare inter-industry relationships. It is designed to show, on the one hand, what are the inter-industry relations at any one time and on the other, how the economy would react to a change in one or all of these sectors while the prior inter-industry relationships would continue to hold true. In the context of economic development, it is claimed, that input-output analysis can indicate the sectors that are most suitable for development[2] and it can also trace the effects of such development on the requirements of resources such as foreign exchange, capital and important physical items such as steel, which tend to be scarce under conditions of underdeveloped countries.

Input-output work consists of (a) computing the input-output table or matrix: this is a method of assembling and integrating economic data which is purely descriptive of the economy at a given point of time and (b) input-output analysis which is a method of using these data to illuminate certain problems connected with economic development.

An input-output table for the economy shows in a schematic form input-output relations within broad sectors, say, agriculture, industry and services. In the rows of the table are indicated the value of output of an industry and in columns the value of inputs required by that industry to carry on production.

With the data arranged as in a table of this type it is possible to come to some conclusion about the relative importance of each item of input in the output of an

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* The paper has been submitted by the author in his personal capacity and, therefore, the responsibility for the views expressed is that of the author himself.

1 This section is based largely on Leontief's work and especially on his article "Input-Output Economics" (*Scientific American*, October 1951).

2 *e.g.*, Comparison of capital output ratios in alternative sectors could show the areas where investment of capital could contribute more to the national income.

industry. For instance, with total output of 956 from agriculture, the input of food, drink and tobacco may be 66 or the input of food, drink and tobacco is roughly 0.07 unit per unit of agricultural output figure of 0.07, is called the input coefficient of food, drink and tobacco into the agricultural industry, and such coefficients could be calculated for all sectors.

So far, the matrix has been considered merely in its role as a description of the economy at a point of time. By making assumptions about the input coefficients, it could be used for an analysis of changes. One such assumption is that of fixed input coefficients which is contrary to a number of accepted economic tenets and known facts. The assumption, however, does enable one to follow at least roughly the probable repercussions throughout the economy of a change in any one part of it.

This method of following through to the end results of all the repercussions known as inverting the matrix was developed and used by Leontief. By inverting the matrix, it is possible to give a general solution relating to the level of final demand to the level of output of each sector. It would be beyond the scope of this note to go into the question of such inversion and its limitations. A major practical difficulty, however, is that the number of multiplications involved in solving the simultaneous equations is the cube of the number of sectors, a fairly simple matrix necessitating the use of mechanical computors. More important is the rigidity of the analysis preventing due account being taken of changes in the coefficients as limits of productive capacity are reached or as imports are substituted for domestic production. For many reasons it is desirable to have a more flexible approach and this is is provided by what is called 'the iterative approach'. The iterative method consists in following, step by step, the results of a change in any one sector. It is possible at any stage of iteration to vary the coefficients used ; one can take account of changes in coefficients resulting from the use of different types of equipment and different productive processes at different levels of production, if estimates can be made of what these changes will be. Secondly, it is possible to take account of limits set by existing productive capacity.

It will have been noted that data entered in tables are to be in the form of values. This is done for the sake of convenience so as to be able to give an aggregate of the various items of output and input. For instance, taking the agricultural industry, it is necessary to take an aggregate of output of wheat, jute, maize, animal products which can be added only in value terms. Similarly, on the input side it is necessary to add together fertilizers, machinery, transport services and so on.

Value of output depends on the quantity produced and the price per unit. Therefore, the table can be considered in two aspects, either as an indication of quantities or as an indication of prices and thus it can be adapted for analysis of quantity changes or price changes. If used to illuminate problems concerning quantities it is assumed that the prices remain stable and the variations in figures relate to quantities only. In this case the coefficients can be considered as indicators of the quantities required for each unit of output.

The classical type of input-output analysis developed by Leontief depended on the assumption of fixed coefficients with a view to making a complete analysis of the whole economy. However, the assumption is not consistent with facts.

There will, therefore, be need for periodic revision of the input-output matrix. It is also not altogether true that input-output analysis depends on the assumption of fixed coefficients but it does require that any changes should be predictable. The more serious objection in application of input-putput analysis to the agricultural sector of the economy is that the coefficients are subject to unpredictable changes on account of weather and perhaps other factors.

Critics have also pointed out that the input-output analysis does not take into account the possibilities of growth in the economy. This is not altogether correct for an element of dynamism could be introduced assuming that capital requirements and capital availabilities are related to levels of output.

A good deal of criticism has been focussed on the amount of information required and the amount of labour involved in setting the statistical table. The time involved in working out a matrix has been as much as 10 years for countries which have already done this type of work. Thus, the information, tends to be historical by the time it is ready for use.

II

LIMITATIONS OF INPUT-OUTPUT ECONOMICS IN AGRICULTURE [3]

Most of the input-output work began in the U.S. and subsequent developments, refinements, etc., have taken place in highly industrialised countries. Generally speaking, the problems connected with agriculture have been given little or no attention. A very marked difference between agriculture and industry is the occurrence of chance variations in the relationship between input and output in agriculture. These variations are due to vagaries of weather principally, but livestock and crop epidemics also are important causal factors. Variations affect both input and output side of the calculation; a good season may raise output and reduce costs per unit; a livestock epidemic might lower total output while increasing costs of veterinary services, etc.

Input coefficients are thus likely to be much more variable in agriculture than in industry and to vary in an unpredictable manner. A common way of dealing with this problem is to take averages for a number of years but for input-output work this introduces further complication. In the first place, this will obscure the effect of technical change during the period on which the average is based. The input coefficients will in fact not relate to any state of technique which actually existed and will therefore be an unsatisfactory basis for analysis. Of course, if the period is short, it is unlikely that the amount of technical change would be sufficient to affect the coefficients but by contrast the shorter the base period the greater will be the disturbing influence of weather variations. The second point concerns the repercussions on inputs of other industries. According to the assumptions of input-output work there is a unique relationship between various inputs and factors of production engaged in an industry. This relationship could in theory be discovered from the industrial data either at a point of

3 For detailed list of limitations a reference may be made to R.A. Bishop: "Input-Output Work as a Basis for Development Planning" (*Monthly Bulletin of Economics and Statistics,* May 1956), from which a number of ideas have been drawn for this section.

time or over a period of time, but whichever the alternative chosen, the time-reference must be the same for all factors in the matrix It would not be correct to use averages over time for some industries and actual figures for a given point in time for others. It may be possible for practical purposes to ignore this problem where agriculture is a relatively small sector of the ecomomy or where agricultural inputs are only a small proportion of total inputs, industry by industry but this is not likely to be the case.

A pronounced difference between agriculture and industry lies in the manner of capital formation. 'Capital formation', apart from pipe-line stocks is in any case, a special problem for input-output analysis and requires special treatment since inputs of capital are clearly only related indirectly to output after a considerable lapse of time. But methods of dealing with capital formation assume that the construction of capital goods takes place in a different economic sector from that which uses them. While this assumption is reasonable for industry it is less so in agriculture. The crop farmer who wishes to raise the fertility of the soil will do much of the work himself, the livestock farmer who wishes to increase his cattle numbers can either buy in from another farmer or he can breed his own additional stock. In either case operations remain within the agricultural sector. In theory the best solution would be to define separately the capital producing sectors in agriculture but this would be highly unrealistic, besides involving some very drastic and arbitrary assumptions. Failing this solution it seems necessary to accept the fact that the agricultural sector will include inputs directed to two purposes, some of the inputs will be producing input which move out of the sector—this is on par with other industrial sectors in the matrix; other inputs will be producing capital goods which are themselves to be used in the process of future agricultural production—this has few parallels elsewhere in the matrix. Input coefficients will be distorted by the extent of the production for capital. If the proportion of production for capital to production for output remained constant, the distortion of input coefficients could be accepted and would be content with a given constant percentage increase in output in subsequent periods. In fact, the proportion changes somewhat over time and therefore one must conclude that the distortion of input-output coefficients in agriculture will affect the validity of the results of the analysis.

A special difficulty is that problems of aggregation though no different are much more difficult in agriculture than in industry. *Prima facie*, it would be more desirable to have a sector breakdown by commodities than by types of enterprise. The objection to an enterprise classification is that, for instance, livestock farms may produce small amounts of crops and *vice versa*. Within the total volume of output of livestock farms, there is room for a good deal of change in composition and the same is true on the input side. Thus it seems clear that if sectors are defined by types it is not possible to make the characteristic classification that input coefficients are uniquely defined. However, a sector breakdown by commodities is equally open to objection. It is well-known that the majority of commodities are produced in conditions of joint production; that many different combinations of commodities are to be found and that there is great variation in the degree of "specificity" with which inputs would be allocated to individual commodities. This means there is no firm basis for the distribution of inputs by commodity and consequently one concludes that the input coefficients here also are not uniquely defined.

Another difficulty appears when attention is turned to the way in which an expansion of output takes place in agriculture. In agriculture, expansion, even in the short run, means necessarily a change in the input coefficients. This is a result of numerous types of farm enterprises and of the very great number of farms, in relation to total output, with wide variations in the level of efficiency in the use of inputs. It is a common feature of agriculture that expansion both of output and input, takes place unevenly among the various types of farms and at various levels of efficiency. Both the average composition of inputs and the average composition of output will change and thus input coefficients are not stable as expansion takes place. This is true,even if it is assumed that expansion will not cause a change in the productive set-up of individual farms but this assumption is not justifiable. Expansion on individual farms takes place as a result either of changes in the system of farm organisation or by changes in the level of use combination of input factors in given farm enterprises—as in the intensity of feeding cows or pigs or in applying fertilizers to crops. Because of the tendencies towards diminishing returns these will mean shifts in coefficients. These changes taking all farms together will almost always mean a change in the characteristic input coefficients of the agricultural sector. All this is merely to say that the assumption of fixed coefficients in agriculture is untenable and the derivation of new coefficients as output changes will be a very difficult process depending on farm budgetary and farm management analysis.

These are some of the difficulties in applying input-output technique to the agricultural sector. It is not suggested that there may be no solutions but certainly less work has been done here than in other sectors. Even for the economy as a whole it is clear that the subject is still in an experimental stage.

III

INPUT-OUTPUT RELATIONS IN INDIAN AGRICULTURE

In practice, input-output analysis or Activity Analysis or Linear Programming has ranged from the studies of whole economies as for instance Leontief's "The Structure of the American Economy" to problems of choosing a minimum cost dairy-feed.[4] It has been used to illustrate the choice of possible farm enterprises and for determination of choice of a combination of enterprises which will maximize total revenue. One such example is indicated in a recent issue of "*The Economic Record*".[5]

In India, the data have been inadequate for construction of an inter-industry matrix. Even for application of input-output analysis to the choice of individual farm enterprises or of a combination of farm enterprises, there are no data.[6]

4 *Journal of Farm Economics*, August 1951.

5 F.G. Jarrett's "Choice of Farm Enterprizes by Linear Programming"—*Economic Record*, August 1957.

6 Except for the earlier pathbreaking studies of the Gokhale Institute of Politics and Economics on Wai Taluka and the Investigations of Punjab Board of Economic Enquiry. Very recently the following two studies have attempted a sort of Input-Output approach: (1) G. D. Agrawal and S. M. Pathak: "Budgeting Approach in Farm Planning " (*Agricultural Situation in India*, June 1957), (2) E. F. Daniel: "Planning Farm Development, A Progress Report" (*Agricultural Situation in India*, February, 1957).

To remove this deficiency, studies in Economics of Farm Management were started under the overall direction of the Directorate of Economics and Statistics and the Research Programmes Committee of the Planning Commission in five typical regions, *viz.*, Bombay, Madras, Punjab, Uttar Pradesh and West Bengal from 1954-55 and were extended to Madhya Pradesh for 1955-56. The results of investigations if continued over years would turn up data suitable for input-output analysis, for national policies aimed at rational land use and for individual entrepreneur aiming at a maximization of his returns. The results obtained in these five States for 1954-55— hitherto unpublished —show that with some exceptions farm business is generally in deficit, the output-input ratio being less than unity.[7] It is also apparent that larger the size of farms the better the farm management results, generally speaking output-input ratio being greater than unity. With larger inputs per acre, output results, however, are poorer even on the larger (as on smaller sized) farms, substantiating to an extent the law of diminishing returns. The results have also indicated that certain regions appear better suited for cultivation of certain crops (Salem in Madras for rice). It would be clear that the data presented are just sufficient for confirming the uneconomic character of Indian agriculture and perhaps the high labour input coefficient of agriculture, but not for more ambitious applications of input-output analysis such as determination of land use. It is also interesting in this context that the input coefficient obtaining for a group of farms by one method of obtaining data, *viz.*, the survey method has at times been different from results obtained for a similar group of farms surveyed under the cost-accounting method. These Government studies in Farm Management are scheduled to cover a period of three years. When results of surveys over years are available it may probably be possible to see more clearly the input-output relationships in Agriculture, which may be subject, however, to limitations to which such analysis itself is subject.

With a larger number of surveys covering a number of areas, it may become possible to build up a sufficiently stable set of average input coefficients which may help to build the inter-industry matrix for India—which is probably the best that could be done under the circumstances—which may help the forecasting of raw-material needs and in turn the estimating of probable agricultural inputs. At the same time a larger number of surveys would throw up data sufficient enough to pick and choose between alternative use or the combination of uses (of his land and resources)which may, from the economic point of view, be the most rewarding.

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7 *Vide* Statistical Appendices to this note based on these Studies in Farm Management.

STATISTICAL APPENDIX I

COSTS AND TOTAL VALUE OF OUTPUT PER ACRE UNDER COST ACCOUNTING AND SURVEY METHODS OF INVESTIGATION IN MADRAS

(In Rupees)

Size-group (acres)	Area of Hldings		Total value of Inputs		Total value of Output		Ratio of Output to Inputs	
	C.A.M.	S.M.	C.A.M.	S.M.	C.A.M.	S.M.	C.A.M.	S.M.
0— 2·5 ..	64·84	177·37	248·1	240·6	181·1	254·6	0·7	1·1
2·5— 5·0 ..	191·70	374·26	190·4	207·4	160·9	141·8	0·8	0·7
5·0— 7·5 ..	178·66	36?·76	138·5	154·7	125·0	91·1	0·9	0·6
7·5—10·0 ..	213·79	241·91	152·5	167·3	145·8	109·5	1·0	0·7
10·0—15·0 ..	188·20	361·94	102·2	92·4	68·5	66·3	0·7	0·7
15·0—20·0 ..	230·44	253·38	77·8	86·0	75·3	64·0	1·0	0·7
20·0—25·0 ..	89·99	178·14	43·3	139·0	31·0	96·6	0·7	0·7
25·0—above ..	358·47	472·26	84·5	87·2	101·0	68·5	1·2	0·8
Overall ..	1516·09	2422·62	114·7	139·6	108·1	103·6	0·9	0·7
Salem ..	481·27	749·43	165·6	230·6	133·8	133·2	0·8	0·6
Coimbatore ..	1034·82	1672·59	99·3	107·3	94·2	86·3	0·9	0·8

C.A.M. = Cost Accounting Method. S.M. = Survey Method.
Source:—Studies in the Economics of Farm Management in Madras for 1954-55.

STATISTICAL APPENDIX II

TOTAL INPUTS AND OUTPUT IN AHMEDNAGAR DISTRICT IN DRY AND PARTIALLY IRRIGATED HOLDINGS ARRANGED ACCORDING TO SIZE-GROUPS BY SURVEY METHOD IN BOMBAY

Size-groups in acres	Dry Holdings				Partially Irrigated Holdings			
	Total No. of Holdings	Total value of Inputs (Rs.)	Total value of Output (Rs.)	Ratio of Output to Input	Total No. of Holdings	Total value of Inputs (Rs.)	Total value of Output (Rs.)	Ratio of Output to Input
Below 5	6	76·22	60·50	·8	16	88·99	63·74	·7
5 and below 10	13	63·45	47·08	·7	15	71·52	53·22	·7
10 ,, ,, 15	13	32·60	29·67	·9	15	45·29	42·47	·9
15 ,, ,, 20	7	30·48	22·48	·7	16	51·05	35·14	·7
20 ,, ,, 25	7	18·63	11·23	·6	5	36·92	25·20	·7
25 ,, ,, 30	8	26·02	23·22	·9	11	40·37	27·84	·7
30 ,, ,, 50	8	22·30	17·64	·8	21	37·29	27·99	·7
50 and above ..	3	26·68	9·76	·4	15	33·45	28·06	·8
Total ..	65	29·71	18·02	·6	114	40·50	31·35	·8

Source:—Studies in Economics of Farm Management in Bombay—Report for the year 1954-55, Table No. 4·13

STATISTICAL APPENDIX III

TOTAL INPUTS AND OUTPUT IN NASIK DISTRICT IN DRY AND PARTIALLY IRRIGATED HOLDINGS ARRANGED ACCORDING TO SIZE-GROUPS BY SURVEY METHOD IN BOMBAY

Size-groups in acres	Dry Holdings				Partially Irrigated Holdings			
	Total No. of Holdings	Total value of Inputs (Rs.)	Total value of Output (Rs.)	Ratio of Output to Input	Total No. of Holdings (Rs.)	Total value of Input (Rs.)	Total value of Output	Ratio of Output to Input
Below 5	10	51·83	35·35	·7	11	165·02	154·65	·9
5 and below 10 ..	12	48·00	34·65	·7	10	134·19	105·53	·7
10 ,, ,, 15 ..	6	50·05	42·06	·8	4	103·37	131·20	1·3
15 ,, ,, 20 ..	7	32·65	33·96	1·4	7	60·53	50·83	·8
20 ,, ,, 25 ..	5	58·68	47·59	·8	3	55·31	49·97	·9
25 ,, ,, 30 ..	1	31·26	38·88	1·2	33	45·59	19·91	1·1
30 ,, ,, 50 ..	10	36·15	50·51	1·4	4	41·70	35·98	·9
50 and above ..	2	30·70	58·97	1·9	4	30·91	37·85	1·2
Total ..	53	39·24	45·97	1·2	46	61·25	59·17	·9

Source:—Studies in Economics of Farm Management in Bombay—Report for the year 1954-55, Table No. 4·14

STATISTICAL APPENDIX IV

PER HOLDING VALUES OF INPUT AND OUTPUT AND RATIO OF OUTPUT TO INPUT IN THE U.P.

Size-group (acres)	Number of Holdings		Per holding value in Rupees: INPUT		Per holding value in Rupees: OUTPUT		Ratio of Output to Input	
	Cost Accounting Sample	Survey Sample	Cost Accounting Sample	Survey Sample	Cost Accounting Sample	Survey Sample	Cost Accounting Sample	Survey Sample
Below 5	47	121	1,139	1,081	1,037	1,019	0·9	0·9
5—10	71	133	1,892	1,797	2,249	2,049	1·3	1·1
10—15	37	72	2,140	2,170	2,721	2,793	1·3	1·3
15—20	17	40	2,594	3,335	4,021	4,206	1·4	1·3
20 and above	21	31	4,099	4,907	6,829	6,998	1·7	1·4
Average	193	397	2,084	2,044	2,699	2,474	1·3	1·2

Source:—Studies in Economics of Farm Management in U.P.

STATISTICAL APPENDIX V

INPUT-OUTPUT PER ACRE IN RUPEES

(PUNJAB)

Holding size-group (acres)	Percentage of selected Holdings		Input		Output		Ratio of Output to Input	
	C.A. Method	Survey Method	C.A. Method	Survey Method	C.A. Method	Survey Method	C.A. Method	Survey Method
Amritsar District	—	—	184	205	176	177	0·95	0·86
Ferozepore District	—	—	138	154	130	131	0·94	0·85
0—5 ..	6	4	226	264	174	184	0·76	0·70
5—10 ..	24	30	197	223	178	176	0·90	0·78
10—20 ..	43	38	164	189	155	160	0·94	0·84
20—50 ..	23	24	146	159	137	137	0·93	0·86
50 and above ..	4	4	121	126	122	123	1·01	0·97
Overall average	100	100	153	172	145	147	0·94	0·85

Source:—Studies in Economics of Farm Management in Punjab : 1954-55.

STATISTICAL APPENDIX VI

Average Input—Output per Acre in Rupees

(West Bengal)

Holding size-group (acres)	Number of Holdings		Hooghly						24 Parganas					
			Input		Output		Ratio of Output to Input		Input		Output		Ratio of Output to Input	
	C.A. Method	Survey Method	C.A. Method	Survey Method	C.A. Method	Survey Method	C.A. Method	Survey Method	C.A. Method	Survey Method	C.A. Method	Survey Method	C.A. Method	Survey Method
0·01—1·25	65	131	315	270	307	294	0·97	1·08	268	200	260	169	0·99	0·80
1·26—2·50	55	94	279	235	285	221	1·02	0·94	173	187	199	160	1·15	0·85
2·51—3·75	28	69	288	190	238	184	0·82	0·97	170	178	221	162	1·31	0·91
3·76—5·00	23	48	219	200	223	200	1·01	1·00	164	187	178	144	1·08	0·77
5·01—7·50	17	35	232	206	248	242	1·06	1·21	162	162	188	161	1·16	1·00
7·51—10·00	8	12	231	154	250	152	1·08	0·98	124	129	207	172	1·66	1·33
10·00—15·00	3	9	278	185	278	187	1·00	1·01	106	132	62	108	0·59	0·81
Above—15·00	1	2	157	132	153	103	0·97	0·78	—	202	—	121	—	0·60
All Farms	200	400	235	205	243	201	1·03	0·98	165	178	193	152	1·16	0·85

Source:—Studies in Economics of Farm Management in West Bengal: 1954-55.

OUTPUT-INPUT RELATIONS IN INDIAN AGRICULTURE*

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Introduction

The output-input relations as observed in the study—Economics of Farm Management in U.P. form the subject matter for this paper. The investigation was conducted on 600 randomly selected farms in two districts of western U.P for three years 1954-57, on 200 of them by the cost accounting and on the remaining 400 by the survey method.

The output in agriculture is determined not only by the quantity of input factors such as seed, manure, labour, etc., consumed in the process of production but also, by and large, by the quality of land and subsequent improvements effected in it by the human agency. The term land is used here in its widest sense as generally defined in text books on Economics. In addition to the input factors mentioned above, management also plays quite a significant part influencing the volume of output in farming.

Agricultural Features of the Region

For a clear understanding of the output-input relations discussed in this paper, a brief account of the agricultural features of the region studied and its farmers will be found useful. The farmers belong to one of the most industrious and skilled farming communities of the country. Together with their women folk they are known for their sturdiness, good health and relatively better diet. Their draught cattle, the bullocks of *hariyana* breed are well-known for their stamina and strength.

The soil in general is light and of average fertility. The farmers of the region pay good attention to its cultivation. The fields are well levelled and excepting a few places are well drained. Nearly 69 per cent of the cultivated area is irrigated, mainly by canals. The annual rainfall is about 29″. The farmers are mostly peasant owners or hold *sirdari* rights which for all practical purposes is equivalent to peasant proprietorship. Relatively speaking transport facilities are also well developed. The average area of sample farms is 10.36 acres. Nearly all the land of the farms is cultivated. The farms below 5 acres form 24 per cent of the total number but account for only about 8 per cent of the total land under cultivation. More than half the farms are between 5 and 15 acres and command nearly 56 per cent of the total cultivated area. Farms of 20 acres and above constitute only about 11 per cent of the total number but have about 29 per cent of the total area under them. Fragmentation is quite a serious evil in the region.

*The data used in this paper are from the study 'Economics of Farm Management in U. P.' which has been financed by the Research Programmes Committee, Planning Commission, Government of India. The views expressed in this paper are entirely in the personal capacity of the author.

The principal crops grown in the region are sugarcane and wheat occupying about 20% and 25% respectively of the gross cropped area. Sugarcane contributes nearly 40% to the gross income. About one-third of the total cultivated area is double cropped. The area under sugarcane, although it is a multi-seasoned crop and occupies the field for the whole year, is treated as single cropped; otherwise the percentage intensity of cropping would appear much higher. The year 1954-55 was agriculturally a normal one and the crops did not suffer any notable damage by natural calamities, insects and diseases. The crops suffered loss due to bad weather conditions in 1955-56 but some improvement in agricultural prices as compared with the previous year compensated for it to some extent. Still, gross income received in 1955-56 was less than that in 1954-55.

OUTPUT-INPUT RELATIONSHIP AND SIZE OF FARM

The following table shows the output-input relationship according to size of farm for 1954-55 and 1955-56 by both the cost accounting and survey methods. The inputs include all those items on which cash and kind expenditure have been incurred and also items such as family labour, farm produced manure, etc. The imputed values of family labour and farm yard manure have been included in the total cost of input. Similarly the gross income represents the value of total produce and includes the imputed value of by-products, *e.g.*, bhusa (dry chaffed stalks).

TABLE I—INPUT-OUTPUT RELATIONSHIP BY THE SIZE OF FARM

Size-group (in acres)	Output-Input Ratio			
	Cost Accounting sample		Survey sample	
	1954-55	1955-56	1954-55	1955-56
Below 5	0·9	1·1	0·9	1·1
5—10	1·3	1·2	1·1	1·2
10—15	1·3	1·1	1·3	1·3
15—20	1·4	1·2	1·3	1·2
20 and above	1·7	1·4	1·4	1·3
All farms	1·3	1·2	1·2	1·2

The notable conclusion that emerges from the study is the low ratio of output to input. It is only about 1.2 for all the farms. It is, therefore, quite obvious that the farmers of the region work on a very low margin and the depressed conditions of the farm economy is also clearly brought out. This is so even in an area which represents one of the best agricultural regions, is inhabited by a skilled farming community, in which irrigation and transport facilities are well developed and sugarcane, an important cash crop, is the principal crop. This draws pointed attention to the need for the adoption of all possible measures to improve the output-input ratio in order to leave an adequate margin to the farmer to meet not only his operating expenses in adverse situations as well but also to provide him with some disposable income for investment in agricultural improvements and betterment of his own level of living.

It will be seen that the output-input ratio increases in general with the increase in the size of farms. On farms below 5 acres, *i.e.*, those in the smallest size-group, the value of output was not sufficient to meet the total cost of input factors in 1954-55 and it was just enough to cover it in 1955-56. On farms of 5 acres and more the surplus over the total cost of inputs ranges generally between 20% and 40% of the value of output which, on consideration of the fairly frequent and large fluctuation in yield and agricultural prices, cannot be treated as adequate. The larger output-input ratio on farms in higher size-groups is not due to any higher value of output in their case as will be clear from the table below.

TABLE II—VALUE OF OUTPUT PER ACRE BY SIZE OF FARMS

Size-group (in acres)	Output values per acre			
	Cost Accounting sample		Survey sample	
	1954-55	1955-56	1954-55	1955-56
Below 5	313·5	276·6	311·6	291·4
5—10	300·6	239·5	280·9	252·7
10—15	253·8	204·1	255·3	240·8
15—20	238·9	200·3	252·5	215·6
20 and above	252·1	204·9	236·7	190·4
All farms	264·1	219·8	262·9	234·1

It will be seen that the value of output per acre is rather higher in the case of farms in the lower size-groups as compared with the farms in higher size-groups. This is mainly due to a higher intensity of cropping on smaller farms, as will be clear from the figures given in the table below:

TABLE III—INTENSITY OF CROPPING BY SIZE OF FARMS

Size-group (in acres)	Intensity of Cropping			
	Cost Accounting sample		Survey sample	
	1954-55	1955-56	1954-55	1955-56
Below 2·5..	152·6	142·0	144·7	155·0
2·5— 5·0..	155·1	146·5	139·5	141·5
5·0— 7·5..	146·4	141·8	135·2	137·3
7·5—10·0..	139·5	137·7	133·1	134·0
10·0—15·0..	127·1	135·8	125·0	137·1
15·0—20·0..	128·1	129·0	127·6	134·2
20·0—25·0	127·5	134·7	117·5	121·8
25 and above	113·5	125·2	117·9	123·0
All farms	131·3	134·7	127·7	133·6

Even with a higher value of output per acre in the case of farms in the lower size-groups the output-input ratio is more favourable on larger farms. This is because of a correspondingly greater reduction in the cost of input factors per acre in the case of latter.

TABLE IV—COST OF INPUT PER ACRE BY SIZE OF FARMS

Size-group (in acres)	Cost of input by size of farms			
	Cost Accounting sample		Survey sample	
	1954-55	1955-56	1954-55	1955-56
Below 5	343·7	258·8	330·8	269·6
5—10	252·7	209·0	245·7	208·9
10—15	184·0	185·2	198·2	185·4
15—20	172·0	173·1	200·1	174·9
20 and above	151·3	145·0	166·0	144·3
All farms	203·9	184·7	217·2	189·5

It will be seen that the cost of input per acre on the farms in the highest size-group is about 70% of the average for all the farms and only half of the cost on the farms in the lowest size-group. An examination of the break-up of the total cost shows that the cost of nearly each input factor is lower on the larger farms as compared with the smaller ones. However, the chief factors responsible for a substantial difference in the cost of total input on the larger and smaller farms are the bullock and human labour. Their cost in the highest size-group of farms is nearly half as compared with the smallest size-group of farms.

OUTPUT-INPUT RATIO BASED ON ACTUAL INCOME AND EXPENSES

By actual income and expenditure is meant the cash and kind expenditure incurred by the farmer and the cash and kind income obtained by him. Accordingly, items such as family and exchange labour, farm produced manure, etc., do not enter into the expenditure. Similarly the value of farm produced dry and green fodders consumed by the draught cattle is not treated as an item of receipt. The output-input on the basis of actual income and expenses as explained above is given below for 1955-56.

TABLE V—OUTPUT INPUT RATIO BASED ON ACTUAL INCOME AND EXPENSES

Size-group (in acres)	Cost Accounting sample	Survey sample
Below 5	2·13	1·99
5—10	2·07	2·01
10—15	1·99	2·10
15—20	1·98	1·87
20 and above	1·97	1·99
All farms	1·99	1·99

The average output-input ratio for all the farms is 1.99 and varies between 1.99 and 2.13. It will be seen that its range of variation is not so wide as when the imputed value of all the items, *i.e.*, farm produced manure and by-products is included in the output and similarly the inputs include value of family labour, manure, etc. There is not much difference between the output-input ratios on larger and smaller farms. An obvious reason for this seems to be the fact that the advantage of larger area in the shape of reduced cost of input factors particularly bullock and human labour on the farms in the higher size-groups is more or less neutralised by a relatively much larger wage bill on them as compared with the smaller farms. On the latter, mostly family labour is used. Since it is not charged the wage bill on them is quite small. Even on excluding the family labour which forms quite a substantial part of the total input cost there is hardly any significant increase in the output-input ratio. The most striking feature of our farm economy brought out by this study is the characteristically low output-input ratio even in an area which agriculturally is much better off as compared with many parts of the country.

RANGE OF VARIATION OF OUTPUT-INPUT RATIO

The output-input ratio has been grouped into 8 size intervals and the number of farms in each size-group is given below:

TABLE VI—DISTRIBUTION OF FARMS ACCORDING TO OUTPUT-INPUT RATIO

Output-Input ratio	Distribution of farms	
	Number	Percentage
Less than 0·5	3	1·5
0·5 —0·75	9	4·5
0·75—1·00	51	26·0
1·00—1·25	73	37·1
1·25—1·50	41	20·8
1·50—1·75	16	8·1
1·75—2·00	1	0·5
Above 2·00	3	1·5
All farms	197	100·0

It will be seen that the highest number of farms is concentrated in the output-input ratio of 1.0 to 1.25. The number of farms in the smallest and highest size-intervals of output-input ratios is very low. Among the highest class intervals of output-input ratio, only the class interval of 1.50—1.75 has 16 cases. An analysis of the 16 farms shows that nearly all of them are of 5 acres and more, 9 of them being above 15 acres. These farms are situated in canal irrigated villages and sugarcane produced on them is disposed of to mills. Their average yield is also high. On the basis of this limited observation, the higher output-input ratio in this region seems to be associated with larger size of the farms, canal irrigation and sale of sugarcane to mills.

CONCLUSION

The output-input ratio even in one of the best agricultural tracts of India is quite low. The ratio becomes still more unfavourable in agriculturally bad years or during the period of low agricultural prices. The seriousness of the situation becomes all the more emphasised when the low ratio is judged against the background of small size of farms and low absolute values of output and input. The input on most of the farms studied varied between Rs. 1000 and Rs. 2500. Therefore, the average output-input ratio of 1.2 simply means a surplus equivalent to only about 20% of this low total value of input. In countries where the size of farms is large and the value of output and input are high, even a low ratio gives a relatively much larger surplus. The recent farm management study in U.P. has shown that inspite of the land being the most scarce factor it is not being put to efficient use and this accounts for the low output as well as low output-input ratio. The vicious circle of low output, inefficient utilisation of land and low input can be broken only when the factors responsible for the low output as well as low output-input ratio receive due attention in formulating the agricultural plans for inprovements.

INPUT-OUTPUT RELATIONS IN INDIAN AGRICULTURE*

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A scientific study of input-output relationship or production functions in agriculture provides a sound basis for developing the economic aspect of agricultural production on a pattern that would guide farmers to operate at the least-cost and highest-profit combinations. This relationship is approached from two broad aspects. The first involves the relationship of agriculture to an individual farmer and the second applies to relationship between agriculture and the nation as a whole. These two aspects cover, in a large measure, a greater area of a common ground and have a social bearing on the welfare of the community.

But at the same time the input-output relationship directs attention to the conflict involved between the roles of farm management and agricultural economics. The interest of an individual farmer, which is the sphere of farm management,

*The author acknowledges his thanks to Shri R. C. Agrawal, M.Sc. (Ag.), Lecturer in Agricultural Economics for the assistance rendered by him in working out the cost of production figures under different size-groups.

is to get the maximum possible net money value of his produce, while the concern of agricultural economics, especially during the period of food shortage, is to have maximum agricultural production, even though an individual farmer may be getting relatively less money income from his farm business.

The present paper examines the relationship from the standpoint of an individual producer and of the nation as a whole.

CASE STUDY NO. I

An experiment was conducted by the writer himself to find out the input-output relationship between the amount and kind of fertilizers used and yields obtained in the production of maize at the Agricultural College, Kanpur in 1951. The results obtained are summarised below:-

TABLE I—FERTILIZERS INPUTS AND OUTPUTS OF MAIZE

Per Acre

Fertilizer inputs	Total output in mds.	Additional output in mds.	Value of additional output Rs.	Cost of fertilizers in Rupees	Profit or loss Rs.
Control	23·98	—	—	—	—
50 pounds of phosphoric acid	25·25	1·27	18·0	34·8	—16·8
100 " " "	27·85	3·87	58·5	69·6	—11·1
40 pounds of nitrogen	29·76	5·78	88·5	44·4	+44·1
40 pounds of nitrogen + 50 lbs. of phosphoric acid	31·22	7·24	108·0	79·2	+28·8
40 lbs. of nitrogen + 100 lbs. of phosphoric acid	33·57	9·59	144·0	114·0	+30·0
80 pounds of nitrogen	31·84	7·86	117·0	88·8	+28·2
80 pounds of nitrogen+50 lbs. of phosphoric acid	33·47	9·49	141·0	123·5	+17·5
80 pounds of nitrogen+100 lbs. of phosphoric acid	36·12	12·14	181·5	158·4	+23·1

Note:—A basal dressing of 200 mds. per acre of farm-yard manure was applied to the field.

From the above table, it will be apparent at once that in physical term the highest response was obtained when 80 pounds of nitrogen and 100 pounds of phosphoric acid were applied. In money term, the application of 40 pounds of nitrogen alone gave the highest net profit per acre. From the farm management standpoint, one would surely say that the individual farmer should stop at 40 pounds of nitrogen only for securing the largest net profit per acre. But the interest of a nation, particularly when it has to import foodgrains, lies in increasing its total agricultural production and those treatments which give higher physical outputs should be preferred. In the above example, the price of the fertilizer inputs can be reduced by their subsidised sales and thereby reducing the cost of production to enable a farmer to effect improvement in farming technology at a low cost combination.

CASE STUDY NO. II

Farm Business as a Whole

The nation is also interested in having its farm land, labour, capital and management resources so utilised that the amount of each is well fitted to one another over the whole country.

The following analysis of input and output relations is based on a continuous study of the holdings of village Vinayakpur made by the Agricultural Economics Section of the Agricultural College, Kanpur. Although the economy of the village has been influenced by the proximity to the city, yet the findings are of significance, being illustrative of the relationship between inputs and outputs in terms of crop production on uneconomic and economic units of farms.

Table II indicates that the input in terms of human labour is more on the small farming unit on account of more intensive employment of family labour, resulting in an increase in the expenses of cultivation. On such a farm, the extra returns due to higher yields are more than offset by higher cost of production. On a farm approximating an economic unit, there is proper co-ordination of the size to the rest of the input factors, leading to a reduction in the cost of production per unit of output. In the above two farms, there is a minor difference in the outputs, while the difference in the costs of inputs is well marked. The 7.65 acre farm can be considered an economic unit offering a balanced combination of the resources of the cultivator. But the vast majority of our farms are uneconomic resulting in maladjustment of the country's resources.

CONCLUSION

The new emphasis of maximising agricultural production has prominently brought the need of a scientific study of the input-output relationship in agriculture to the front. It is well known that in any production operation, the profit return to each farmer is at the maximum when the last unit of each of the input factors just pays for itself. It means that the resources of the country should be so distributed as to get the highest-profit combination on each farm.

But in our agriculture, the inputs and outputs do not move in the direction of those combinations which yield optimum results, because of the maladjustment

TABLE II—PER ACRE INPUT AND OUTPUT UNDER DIFFERENT SIZES OF FARMS

(Average of 3 years 1951-52 to 1953-54)

Size of Farm	Crop	Percentage distribution of total input expenses								Total expenses	Output in mds.	Total income in Rs.	Profit(+) or loss(—) Rs.	Remarks
		Land	Labour	Bullocks	Seed	Manure	Irrigation	Repairs to dead stock	Interest on working capital					
1·65 acres	Wheat ..	3·6	36·1	34·3	5·2	8·2	3·1	3·3	6·2	203·5	Grain 15·5 Bhusa 28·0	301·0	+ 97·5	Both the holdings have the facility of canal irrigation.
	Sugarcane (Paunda)	2·8	35·2	18·3	15·2	12·4	9·1	2·8	4·2	800·0	640 mds.	1,280·0	+480·0	
	Paddy	2·5	41·5	21·3	3·2	15·3	8·2	4·8	3·2	140·5	Grain 22·8 Straw 60·0	210·0	+ 69·5	
7·65 acres	Wheat ..	3·2	26·4	39·3	5·1	12·2	5·5	3·2	5·1	182·1	Grain 14·8 Bhusa 27·0	288·2	+106·1	
	Sugarcane (Paunda) ..	2·5	30·1	20·2	16·2	13·3	10·4	2·3	5·0	660·2	590 mds.	1,180·0	+519·8	
	Paddy ..	2·7	39·2	26·1	2·2	16·3	8·2	3·1	2·2	122·3	Grain 21·2 mds. Straw 50 mds.	194·6	+ 72·3	

in the resources used. Of the input factors, land and capital are scarce and labour is relatively abundant. Hence there is no effective combination of inputs. There is practically no way of adding acres of land to the size of a farm, but certainly there is scope of adjusting such variable factors as amount of irrigation water, fertilizers, improved seeds, number of sprayings and cultivations to a given size of farm at a low-cost combination. The question of management, family labour, bullock labour and buildings does not arise, because they may be considered as fixed inputs. The crux of the problem is to know what amount of capital as a variable input is needed to obtain a given net return on individual farms. Given the needed amount and kind of capital,a farmer can increase the size of his farm unit or the business on his farm through intensive cropping and thereby striking a better combination of his input factors at a relatively high profit combination.

The relation between the fertilizer inputs and changes in outputs obtained separately and in combination in Case Study No.1 is a typical example to illustrate the necessity of subsidising the production of low-grade farmers to increase their purchasing power through increased production. This would certainly prove economic in the long-run from the standpoint of both the individual farmer and the State. Case Study No. II may be cited as an example to state that the size and the business of the small units of farms can be increased by intensive production to work at low-cost combination.

In the Indian economy, when the production targets have been revised upward, highest profit combination in terms of market prices may not reflect the combination which yield high outputs. The demand of the hour is that the most important single factor of production, namely capital, may cheaply be made available to the farmers to intensify cultivation for maximum production and to allow them to operate their farms at low cost combination. The net aggregates of low cost combinations obtained on individual farms would ultimately lead to the well-being of agriculture and the nation as a whole.

INPUT-OUTPUT RELATIONS IN INDIAN AGRICULTURE*

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In India and other under-developed countries, where the system of subsistence farming is predominant, land utilization has not reached a point of scientific adjustment. The structural adjustment in agriculture when compared to the other sectors of the whole economic system is one of the major factors preventing maximum utilization of land. Indian agriculture is still a way of living, the farms being a family home than a business unit. Under these circumstances the choice

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of the subject "Input-Output Relations in Indian Agriculture" provides a significant opportunity to examine and emphasise the intimate relationship that exist between the two—input and output factors.

Source of Data

The basic data for study have been obtained from 401 randomly selected holdings of different sizes in 16 villages in the upper Ganges Doab in the districts of Meerut and Muzaffarnagar, Uttar Pradesh in the year 1950-51.

Characteristics of the Region

The region of Meerut and Muzaffarnagar districts to which this study refers is one of the best agricultural tracts in Uttar Pradesh and also in India. It is populated by most industrious farmers who are famous for many generations for their farming skill. They are considered to be both good managers and good workers. The noteworthy feature of farming in these districts is that there are few tracts elsewhere with so much made soil by human efforts. The soil is mostly light loam. The normal rainfall is about 29″. Nearly 2/3rd of the cultivated area is irrigated, canal being the major source. The area sown more than once comes to about 33%. The average size of sample holding was about 12 acres. The land is owned by the farmers. The agricultural population forms about 54% of the total in the region. The cultivated area is 80% of the total area. Wheat, sugarcane, gram (pulse), maize and rice are the major crops grown in the area. In addition an appreciable area is under fodder crops (largely sorghum) commanding about 24 and 18 percentages to cultivated and gross cropped area respectively.

Item considered

The items of input considered are human labour (family as well as hired), bullock labour (family as well as hired) and the manure applied. Human labour has been reduced to male adult hour units by treating three female adult hour units as equivalent to two male adult hour units and two child hour units as equivalent to one male adult hour unit. Bullock labour is considered in pair hour units. To make uniformity, the manure applied has been converted in terms of the nitrogen contents of the same. The output is the yield of grain only in the case of wheat and cane only in the case of sugarcane. For the purpose of this study, thus the factors of input, as well as the output have been considered in terms of physical quantities and they have been reduced to a per acre basis.

The crops considered are: (i) Wheat; (ii) Sugarcane planted; (iii) Sugarcane Ratoon.

A correlation study was undertaken between the output and the input per acre on the different holdings. The regression coefficient of output on input which gives the change in the output per acre corresponding to unit increase in the input per acre has also been calculated. The labour items, human and bullock, have been combined and this has been treated as a single variable in the calculation. Since the two factors always go together, it is felt that the procedure is justifiable.

(i) Wheat Irrigated

During the period of study, irrigated wheat was grown on 370 holdings and the total area under the crop from all these holdings was 1436.14 acres.

Labour is the only item of input considered here, since no manuring was done on 84 per cent of the holdings. Even on holdings where manure was applied it was seldom adequate.

The total number of 370 holdings were classified into three groups—according to the amount of labour put in per acre. The groups are :

(i) holdings having an input of less than 600 hour units per acre,
(ii) holdings having an input between 600 and 800 hour units per acre,
(iii) holdings having an input over 800 hour units per acre.

The correlation coefficient, which gives a measure of the strength of the relationship of the factor of input and output and the regression coefficient have been calculated for each group and are presented below.

TABLE I

Group	No. of Observations	Correlation Coefficient	Regression Coefficient x 100
Less than 600 hour units per acre	242	+0·49	+4·28
600—800	110	+0·24	+1·69
800 and above	18	+0·00	+0·02
Overall	370	+0·57	+1·99

The results are quite illustrative. As we move from the lowest labour utilization group, we note that the strength of the relationship between input and output as well as the regression coefficient goes down. In other words, this points to the fact that the rate of increase of the yield per acre corresponding to an increase of one hour unit of labour per acre goes down as the labour utilization per acre becomes higher and higher.

(ii) *Sugarcane Planted*

Sugarcane planted was grown on 373 holdings in the year of study commanding a total area of 990.22 acres. The holdings were grouped into three labour utilization groups, namely, (i) holdings putting less than 550 hour units per acre, (ii) holdings putting between 550 and 850 hour units per acre, and (iii) holdings putting over 850 hour units per acre.

The coefficient of correlation and the regression coefficient for each group and the overall position are given below.

TABLE II

Group	No. of Observations	Correlation Coefficient	Regression Coefficient x 100
Less than 550 hour units per acre	147	+0·18	+37·5
550—850	208	+0·12	+24·5
850 and over	18	+0·00	+ 1·2
Overall	373	+0·31	+31·6

The tendencies shown by the values of the correlation coefficient and the regression coefficient are the same as in the case of wheat.

364 out of the 373 holdings applied manure and the input-output data relating to these holdings were separately studied to find out the strength of relationship between manure input and the output. The correlation coefficient gave a value of 0.41 and the regression coefficient worked out to be 1.29. Thus manure plays an important part as indicated by the very high value of the regression coefficient, and the trend in the data is that for an increase of 100 lbs. of nitrogen content in the manure applied per acre, the increase in the yield per acre is 129 maunds.

Putting the whole data together, a multiple regression study was undertaken among the three factors, yield, labour input and manure input. (The multiple regression equation helps to study the variation in a single factor which is jointly related to a set of factors). The multiple regression equation of X_1 (yield in maunds per acre) on X_2 (labour input in hour units per acre) and X_3 (lbs. of nitrogen applied per acre) worked out to be :—

$$X_1 = 0.46 \quad X_2 + 1.20 \quad X_3 + 57.20$$

The equation means that where the joint effect of the two factors of input, labour and manure, on the yield is considered, an increase of one hour unit of labour per acre tends to increase the yield per acre by 0.46 maunds whereas the yield per acre gets increased by 1.20 maunds due to an increase of 1 lb. of nitrogen content in the manure applied per acre. It should be mentioned here that these results are based on the general tendencies exhibited by the data, though the individual holdings may not all conform to this pattern.

(iii) *Sugarcane Ratoon*

Sugarcane ratoon was raised on 312 holdings in the year of study and the otal area under the crop from these holdings was 445.83 acres. The labour utilization groupings in this case are (i) holdings putting less than 300 hour units per acre, (ii) holdings putting between 300 and 500 hour units per acre, (iii) holdings putting 500 and above hour units per acre.

The correlation coefficient and regression coefficient for each group are shown below:—

TABLE III

Group	No. of Observations	Correlation Coefficient	Regression Coefficient x 100
Less than 300 hour units per acre	190	+0·20	+30·5
300—500	102	+0·06	+15·6
500 and above	20	+0·00	+ 0·9
Overall	312	+0·40	+34·5

The values behave in the same way as that of wheat and sugarcane planted. It can be concluded, therefore, that the proportional increase in the output per acre corresponding to an increase in the input definitely goes down as the input per acre goes up.

240 of the holdings manured the plots and the coefficient of correlation between yield per acre and lbs. of nitrogen applied per acre calculated from these 240 observations worked out to be 0.45. The value of regression coefficient giving the change in the yield per acre per unit increase in the lbs. of nitrogen applied per acre is 1.13 maunds.

As in the case of sugarcane planted the multiple regression equation of X_1 (yield per acre) on X_2 (labour input per acre) and X_3 (lbs. of nitrogen applied per acre) was found to be:—

$$X_1 = 0.32 \quad X_2 + 0.96 \quad X_3 + 179.22$$

The increase in the yield per acre in maunds corresponding to unit increase in the labour input per acre and lbs. of nitrogen applied per acre are respectively 0.32 and 0.96. The constant term in the above equation is as high as 179.22; (theoretically the constant term gives the yield per acre in maunds when the input is zero). The high value can be justified since the crop is sugarcane ratoon.

To establish the optimum level of input in the cultivation of crops, the whole data relating to the input and output have been divided into convenient input groups and the mean values of input and output have been calculated for each. The ratio of output to input in each group gives the output per unit input. The results are presented below.

(i) Wheat irrigated

TABLE IV

LABOUR AND YIELD

Labour hours per acre	Average labour hours per acre	No. of holdings	Yield per acre in maunds	Yield per labour hour in maunds	Yield per additional labour hour in maunds
Less than 400	340	39	10·08	0·030	—
400 - 500	455	91	14·18	0·031	0·0356
500 - 600	548	112	15·51	0·028	0·0143
600 - 700	649	81	17·24	0·025	0·0171
700 - 800	738	29	18·52	0·025	0·0144
800 and above	876	18	22·53	0·026	0·0290

The trend in the ratio is quite clear. The ratio is more or less the same in the first two groups and then a fall in the value can be noted in the succeeding groups. The optimum input can thus be seen to be between 400 and 500 hour units of labour per acre since the ratio of yield to labour is maximum in this group. The yield per additional labour hour however does not give any definite trend.

(ii) Sugarcane planted

TABLE V

LABOUR AND YIELD

Labour hours per acre	Average labour hours per acre	No. of holdings	Yield per acre in maunds	Yield per labour hour in maunds	Yield per additional labour hour in maunds
Less than 400	360	25	406	1·13	—
400 - 500	460	74	482	1·05	0·760
500 - 600	552	100	516	0·93	0·369
600 - 700	643	98	562	0·88	0·505
700 and above	790	76	577	0·76	0·102

Here again we note that as the labour utilization becomes higher and higher the yield per unit of labour utilization goes down steadily. The additional labour hour unit applied also gives a decreasing tendency though no regular trend in yield has been established.

TABLE VI

MANURE AND YIELD

Manure in lbs. of nitrogen per acre	Average lbs. of nitrogen used per acre	No. of holdings	Yield per acre in mds.	Yield per lb. of nitrogen in mds.	Yield per additional lb. of nitrogen in mds.
Less than 50	44	5	444	10·09	—
50 - 75	63	43	446	7·08	0·11
75 -100	89	71	471	5·29	0·96
100 -150	123	128	252	4·20	1·50
150 -200	172	95	591	3·44	1·40
200 and above	228	22	662	2·90	1·27

The yield per unit of manure input is maximum in the group less than 50 lbs. of nitrogen per acre and thereafter the values fall down steadily. It is also seen that towards the initial stages the rate of fall in the value of the ratio is very high. The yield per additional dose of a lb. of nitrogen increases upto the group of 100-150 lbs. of nitrogen, beyond which the effect of additional dose of a lb. of nitrogen gives decreasing values of yield. Thus the law of diminishing returns is clearly illustrated.

(iii) Sugarcane ratoon

TABLE VII

LABOUR AND YIELD

Labour hours per acre	Average labour hours per acre	No. of holdings	Yield per acre in maunds	Yield per labour hour in maunds	Yield per additional labour hour in maunds
Less than 200	123	115	288	2·33	—
200 - 300	240	75	317	1·32	0·25
300 - 400	367	76	393	1·07	0·60
400 - 500	445	26	400	0·90	0·90
500 and above	589	20	435	0·74	0·24

The values of the ratio of yield to labour input behave in the same way as that of sugarcane planted and irrigated wheat. The yield per additional labour hour increases upto 400 to 500 labour utilization group hours per acre while afterwards a decreasing tendency is clearly visible.

TABLE VIII

MANURE AND YIELD

Manure in lbs. of nitrogen per acre	Average lbs. of nitrogen used per acre	No. of holdings	Yield per acre in mds.	Yield per lb. of nitrogen in mds.	Yield per additional lb. of nitrogen in mds.
Less than 50	37	37	297	8·03	—
50 - 75	61	34	306	5·02	0·38
75 -100	90	55	346	3·84	1·38
100 -150	125	82	365	2·92	0·54
150 -200	169	23	424	2·51	1·34
200 and above	229	9	552	2·41	2·13

The tendency of the ratio to fall down when the input of manure increases is exhibited clearly by the values in this case also. The additional dose of a lb. of nitrogen applied does not show any regular trend towards the additional yield obtained.

Summing up, the above analysis clearly brings out the law of diminishing returns. The yield per acre in all the three cases, wheat, sugarcane planted and sugarcane ratoon is found to increase as the input per acre increases, but the values of the ratio of output to input clearly indicate that the return per unit of input goes down as the input increases. The additional dose of labour applied shows a decreasing tendency after a certain stage in cases of sugarcane planted as well ratoon. The extra dose of manure brings about clearly the law of diminishing returns in case of sugarcane planted while no such trend is noticeable in case of sugarcane ratoon.

SOME PROBLEMS OF INPUT—OUTPUT ANALYSIS IN INDIAN AGRICULTURE AND THEIR APPLICATION*

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The analysis of input-output relations in Indian agriculture can be made for various purposes. Generally so far only farm cost studies have been made; their need having been felt chiefly as an aid to price fixation policies. The discussion of the problems also was inevitably carried on with that bias and in that limited context, though farm cost studies have sometimes been equated with input-output studies as well. Knowledge of input-output relations in Indian agriculture throws light on some crucial problems of agriculture, the most important of which

*The author acknowledges gratefully the valuable help of several friends and colleagues in preparation of this paper. The responsibility for the opinions expressed is entirely his own.

is that of the relative efficiency of various combinations of input-factors. If we can assess the relative efficiency of factor-combinations we can improve the utilisation of existing agricultural resources through extension work and also help in the proper allocation of resources yet to be developed. The input-output studies may also help to solve some crucial problems of land reform like determination of the size of an optimum farm, as well as some basic problems of planning like probable projections of output as a result of application of various inputs in given or variable combinations. Since the sphere of usefulness of input-output studies has widened so much, it is all the more necessary that the problems of these studies, their analysis and their application be considered realistically and scientifically.

Input-output studies may be made both in physical and in value terms depending on the purpose for which such studies are being made. For instance, in those cases where production functions of individual inputs are sought to be established with reference to the total output in terms of multiple regression equations, it is immaterial whether the input factors are measured in physical or value terms, provided it is certain that the value of one unit of a particular factor is the same in all the farms under study. But if a relation is sought to be established on the basis of aggregation of all input factors on one side and the total output on the other, it is necessary that all the inputs be measured in value terms.

The measurement of input-output relations in value terms bristles with great difficulties both on the theoretical and the practical plane. These difficulties multiply when use is made of this analysis for policy purposes. The following paragraphs present briefly only a few of these difficulties.

First of all, we shall consider the theoretical problems associated with an analysis of input-output relations in general. These problems arise mainly because of the practice of applying such analysis to dynamic situations even though the assumptions implicit in input-output relations are static.

The basic questions that arise are: (i) Is there any specific and constant relationship between the different factors of production? and (ii) Do the relative prices of these inputs bear any specific and constant relationship with the technical proportions of the various inputs over time? The marginal productivity theory, *a priori*, suggests that under conditions of equilibrium, in perfect competition, there is a proportionality between marginal productivity of the various factors of production and their relative prices. At any given point of time, this would appear to be an indisputable axiom. This, however, explains the equilibrium situation at any one point of time only. What is perhaps more important is to enquire whether such proportionality relationships are constant and uniform for all the various input factors over time. Further, does marginal productivity alone govern this relationship? We shall presently find that it need not be so. The constancy of the relationship betwen marginal productivity and relative prices of any one or several input factors is established only at the points of equilibrium and the establishment of such constancy over time depends upon the assumption of constancy of all the other factors that influence prices. In fact, a dynamic situation, by definition, is one where all these other factors do not remain constant. The constant relationship between the demand for and the supply of various input-factors with marginal productivity also depends upon 'other things remaining the same' which again is an assumption for static situations at given points of time.

The reasons why relative prices of various inputs and their technical proportions are not in constant relationship are several. Firstly, with a given set of relative prices, and a given technique, it is possible to combine various inputs in varying proportions, purely from the engineering point of view. For example, in India, the factor proportions in the cultivation of the same crop on different farms vary within a wide range without any necessary variations in output. This happens not only because of the changes in scale (without any change in technique) but even on farms of similar sizes. The reasons probably lie in the greater availability of particular inputs on various farms, and the relative prices of these inputs do not affect the allocation of these inputs. Secondly, relative prices of some inputs may fluctuate due to causes other than changes in their marginal productivity. For example, creation of employment opportunities in the neighbourhood of a village may suddenly raise the wage rate and make labour relatively an expensive input. This would affect factor proportions on different farms in different ways depending upon the relative scarcity or abundance of labour available to them. But this would by no means increase the marginal productivity of labour in agriculture. Thirdly, fluctuations of demand for the output and consequent fluctuations in prices will alter the input-output combinations in value terms significantly without necessarily altering their technical proportions. Similarly, fluctuations of various elasticities, propensities and expectations and their repercussions on the relative prices of inputs and output also alter the input-output relations without necessarily bringing about any change in their technical proportions.[1]

No doubt in advanced economies there is a certain degree of reciprocity between the technical proportions of factors and their relative prices. Both act and react on each other But the existence of such reciprocity does not mean that there is any uniform or constant relationship between relative prices and technical proportions of inputs.

Thus it would appear that the input-output values given in one situation will differ from these values in a different situation without indicating any necessary and definable relationship between the technical relationships or coefficients of factors of production and their relative prices, or the resultant output and its price.

These problems become still more complicated when discussed in the context of an economy with a large mass of unutilised resources, natural or human. The relative prices of various input factors in such conditions are determined at the point of equilibrium between demand for the factors and that part of their total available supply which is in demand. When there are resources for which there is no effective demand and which may be used in the process of production, if we

1 Incidentally, see an article by Mrs. Joan Robinson on 'Production Function' in *Economic Journal*, Vol. LXV, 1955, p. 71, where, *inter alia*, she writes: "The fallacy at the root of the production function is the idea that it is possible to specify purely technical relations not involving prices, in a human economy."

impute the values of such resources at the prevailing prices of inputs, we would be assuming that the relative supplies of inputs have determined their relative prices which may not be a reasonable assumption.

The complication is futher deepened by the imperfections of factor markets. For that reason, the same input factor may become available to different farms at different prices and in that situation, even if the technical relations of input factors are assumed to be uniform, the input-output relations on different farms in value terms are different. This is because these factor market imperfections make the applicability of a single price to all units of the various inputs difficult, if not impossible.

So much about the limitations of marginal analysis . Coming to the use of analysis in terms of averages, all the difficulties inherent in the determination of the representative firm and its representative inputs reappear. So, it cannot be said that the relative prices of inputs and outputs are determined by the input-output relations of the representative farm.

These difficulties are fully borne out by the recent studies in farm management conducted by the Research Programmes Committee. For example, the U.P. report for the year 1954-55 states that "the small holders, for want of alternative engagements, usually spend more time in farm work and the area of their holdings being small as compared with their bullock and labour resources, they usually resort to more frequent ploughings, weeding and hoeing of their fields."[2] And human labour constitutes as much as about 50% of the total inputs in agriculture, the next in importance being bullock labour. From these studies there appears to exist no homogeneity of even technical relations and technical coefficients of input-factors, not to speak of the homogeneity in regard to the relative prices of inputs and outputs on these farms. However, these problems are not absent when one studies the input-output relations in relatively advanced economies also.

The problems which arise specifically in backward agrarian economies can be considered under three heads:

1. Difficulties in the collection of data, including the problems of statistical sampling, methods of collection, *i.e.*, survey *versus* cost accounting methods of measurement of inputs and outputs, imputation of values and the allocation of these imputed values on different enterprises.

2. Difficulties of analysis, *i.e.*, stratification of homogeneous units, criteria for homogeneity, and development of suitable methods of evaluation and allocation of inputs in different groups of units of production, derivation of single and multiple input production functions for farms of varying structures, and difficulties of approaching the problem of input-output relations on the basis of a farm business approach or farm family approach as, say, in Japan.

3. Difficulties of application of results for the benefit of the practical extension worker, including those of generalising optimal situations, keeping in view the farms of different structures and environments.

2 Report, p. 40.

These difficulties include problems arising from decisions to be made in dynamic situations (where combinations of factors of production or relative prices behave in ways other than assumed). All these difficulties are only too familiar to agricultural economists in India. Many of these difficulties still remain unsolved making it necessary to adopt arbitrary and *ad hoc* solutions in the meanwhile.

In the present context of the Indian agricultural economy, therefore, it is both artificial and dangerous to subject any set of input-output data to a rigorous and highly refined mathematical treatment. Instead, it is possible to revise some of the usual concepts and evolve methods closer to reality and easily applicable under Indian conditions.

One useful line of approach would perhaps be to reconsider the current farm business approach as adopted at present in most input-output studies in India. The suitability of a farm family or farm household approach needs urgent examination. By isolating the non-farm and household part of the activities of a farming unit, we are straining the concepts of output, inputs, etc., and perhaps missing some of the significant factors that influence the allocation of resources and the input-output relations in various farming enterprises. Further, we need also to consider how far the breakdown of the farm into several distinct enterprises should be carried Merely by examining these two questions, one may find that even though highly refined and theoretically perfect input-output studies are not possible to compute, yet for practical purposes, *i.e.*, the use of the extension worker and the policy maker, a more realistic answer to the problems may be given. In this connection, it is necessary to consider the potential benefits of farm budgeting and farm planning, not necessarily on the basis of refined statistical results but on the basis of simple input-output data and by trying to evolve out of it several alternative budgets, on a trial and error method. Thus, what we may lose by way of theoretical refinement will be more than offset by way of the greater benefit which the practical extension worker and through him the farmer derives from research.

INPUT—OUTPUT RELATIONSHIP IN AGRICULTURE*

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Output is a function of several input factors. Intensive application of a single input factor is no doubt outstanding feature of factor-product relationship, but production problem nearly involves combination of factors, and it is rather difficult to speak in terms of a single variable factor of production. Input-output relationship is, therefore, very largely a problem of judicious combination of different input factors and the level at which they are used to obtain optimum production per unit of land and resources. The marginal physical product from any one input factor depends upon quantities of other factors with which it is combined. The marginal productivity of labour, for instance, is very low in

*The author is indebted to Dr. P. C. Raheja, M.Sc., Ph. D.,D.Sc., Head of the Division of Agronomy for making useful suggestions in the paper.

Indian Agriculture, when it is increased in the absence of co-operating capital. The problem of appropriate algebraic functions of multiple factor input-output relationships parallels the problems of single factor, only it is more complex.

The concept of productivity is rationalised when it is qualified in terms of level of input used. The input-output ratios are called production functions which are expressed in the form of factor-product, factor-factor and product-product relationships.

FACTOR-PRODUCT RELATIONSHIP

This is a functional relationship of output per unit of input variable like fertilizer, irrigation, feeding rates, rates of seeding, number of plants in a row, distance between rows and in fact covers the whole problem of intensity of factor use in which economic optima is to be specified. Such a study is necessary because technical efficiency in terms of maximum physical productivity is not always identical with economic optimum.

Technical optima and economic optima are identical when the production function is linear. It is linear when it is homogeneous of the first degree and such a function denotes constant returns to scale. Experience shows that linearity is not possible in case of a single technical unit and although it is possible for the farm as a whole, it is not so common as it was once supposed to be in the farming business.

Economic optima, broadly speaking, is not the same as technical optima when the input-output curve is concave to the origin or convex to the origin and the commodity under production is subject to the law of diminishing returns and increasing returns respectively. The optimal point in all cases can be determined geometrically through tangency of input-output curve and the price line indicating factor-product price ratios. No resource should be employed when the factor-product price ratio is greater than the marginal product.

The optimal point may be determined still more accurately by means of continuous mathematical functions. The author worked out optimum level of fertilization through multiple regression equations[1] in a research article on 'Economic Analysis of Bajra Fertilizer Rate Experiments',[2] conducted at the Institute of Agriculture, Anand, and found that it will not pay to apply more than about 168 lbs., 120 lbs. and 100 lbs. nitrogen in the form of farmyard manure, groundnut cake and ammonium sulphate respectively, against 280 lbs., 160 lbs., and 125 lbs. actually applied. It is, therefore, necessary that all fertilizer recommendations on the intensity of factor input use should be formulated with full consideration given to factor-product relationship study.

The economic optima can also be determined by applying the equation $Px/\triangle x = Py/\triangle y$.[3] This is illustrated from empirical testing of 8 units of groundnut cake applied to bajra crop. The calculated yields were derived through quadratic

1 Spillman or Mitscherlich Exponential form, Cobb Douglas Power Function, Quadratic Function and Quadratic square root function.

2 Being published in the *Indian Journal of Agronomy* (February 1958 issue).

3 $Px/\triangle x$ = added value of factor input. $Py/\triangle y$ = marginal revenue.

square root regression equation and the most profitable rate was worked out at 150 factor-product unit price ratios.

TABLE I—OPTIMUM LEVEL OF APPLYING GROUNDNUT CAKE TO BAJRA CROP

Number of 250 lbs. units of G. N. cake applied/acre	Total output (Derived yield in lb.)	Marginal product ($\triangle y/\triangle x$) for each 250 lb. unit	Value of added G. N. cake at Rs. 21.87 per 250 lb. unit	Marginal revenue ($\triangle y$/Py) Rs.
1	2	3	4	5
0	1201			
1	1449	248	21·87	36·3
2	1592	143	21·87	20·8
3	1718	126	21·87	18·4
4	1835	117	21·87	
5	1946	111	21·87	
6	2053	107	21·87	
7	2157	104	21·87	
8 .. .	2259	102	21·87	

As will be seen from the table, the added value of second unit of groundnut cake applied is Rs. 21.87, whereas the value of the marginal product at this level of input is Rs. 20.8 only. The most profitable rate of groundnut cake applied lies, therefore, between first and second units. Interpolating for the ratio 150 in column 3, the optimum rate works out as under:

$$0.5 + \frac{248\text{-}150}{248\text{-}143} = 1.43 \text{ units}$$

against 8 units actually applied. The most profitable rate worked out through continuous mathematical function (Quadratic square root) was still lower at 1.22 units,[4] which means, economic optima must be specified, if irrational farm resource use is to be strictly avoided.

FACTOR-FACTOR RELATIONSHIP

Given the information as to how any change in the amount of any input factor changes the output, it is possible to work out factor-factor substitution. This is cost minimisation problem. Cost is at a minimum when the ratio of factor prices is inversely equal to marginal rate of substitution of factors. So long as substitution ratio $\frac{\text{(Number of units of replaced resources)}}{\text{(Number of units of added resources)}}$ is greater than the price ratio $\frac{\text{(Price of added resources)}}{\text{(Price of replaced resources)}}$, more of added resources may be used. The general principle to be followed is that cost of replaced resources is greater than the cost of added resources. No further substitution would be economical when the substitution ratio becomes equal to price ratio.

4 Being published in the *Indian Journal of Agronomy* (February, 1958 issue.)

Factor-factor studies can be used in the choice of farm practices. For this purpose, output data per unit of input for alternative practices may be obtained through empirical testing. All that the farmer need do then is to apply probable cost rates to input data for each farm practice and see which of them turns out a unit of output at the lowest cost.

PRODUCT-PRODUCT RELATIONSHIP

Input-output data can also be used to rearrange given resources to allow a greater output of products. This form of function deals with the attainment of the greatest revenue from a given quantity of resources. "The nature of enterprise relationship is dependent upon the nature of production function for each independent enterprise."[5] Product-product relationships are, therefore, a useful tool for determining economic balance in the production of different enterprises and of crop and livestock products in particular. Recently, work has been started on the farm of the Indian Agricultural Research Institute to bring about integration of vegetable farming, crop farming and dairy farming and such a study need be intensified in all farm management studies in the country.

It will be apparent at once that without the knowledge of input-output ratios it is difficult to plan a production operation on sound economic lines. One of the major tasks of farm management research is, therefore, to provide production functions that would determine the effective combinations of factor inputs or the best use of resources.

LIMITATIONS

For a production function to be useful, it must be stable over time. Production function is, therefore, useful where technology and marginal rate of transformation stay fairly constant. Rapid technological developments will diminish the value of the general production function particularly when it is difficult to predict how it will change. Since the tempo of technical development is not very high in case of underdeveloped economies, it is not difficult to predict likely changes in the input-output ratios at least over a shorter period. The Indian farmer can, therefore, benefit from the knowledge of production functions because yesterdays' or todays' function will not become obsolete tomorrow. Conventional input-output relationships as pointed out by Prof. T. W. Schultz, do not provide universal constants of practical use. This may be true when the yield response is established from a single set of experimental data. Where the results have been established from a series of experiments and population sample is more homogeneous, the production functions can provide constants of definite practical use. This is more true in case of agricultural sector of backward economies, where the rates of transformation do not undergo a rapid change. Production function is, therefore, a very important tool in the kit of production economist for analysing the problem of production or resource use. The input-output analysis is already popular for predicting economic magnitude and although we do not have much pudding to eat in this field, empirical testing can determine the areas of practical usefulness of such studies in Indian agriculture.

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5 Heady, E. O.: Economics of Agricultural Production and Resource Use.

Summary

The concept of productivity is useful only when it is qualified in terms of level of input used. The input-output ratios or production function studies are, therefore, very important for determining economic optima.

The optimal point can be specified by means of geometrical method, continuous mathematical functions and the marginal analysis, although it could be done with greater accuracy through multiple regression analysis. The most profitable rate of groundnut cake applied to bajra crop worked out through continuous mathematical function (Quadratic square root equation) at 1.22 units and through marginal analysis at 1.43 units against 8 units actually applied which means, economic optima must be specified to make rational resource use possible.

Input-output data are used to determine least cost combination of inputs by applying the choice indicators of marginal rate of factor substitution and factor price ratios.

To assess the comparative advantages of different farm enterprises, the extension worker needs input-output data from enterprises that are practical alternatives in the area.

Rapid technological developments do diminish the value of production function but such studies in underdeveloped economies, it is hoped, will provide constants of definite practical use.

SOME INPUT-OUTPUT RELATIONSHIPS IN INDIAN AGRICULTURE

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In the matter of input-output relationships in agriculture we are facing one big difficulty. Agricultural output is the result of a large number of variable inputs whereas in order to study the relationship between output and input we generally pick out only 2 or 3 very important inputs such as labour costs or farm animal costs and then consider these inputs in relation to output on farms of comparable size. In actual reality the difference in productivity and in costs and profits arrived at may be due to hidden causes such as comparative managerial inefficiency or comparative redundancy or otherwise of family labour units available for employment due to varying sizes of the farm family. Due to difficulties like this one wonders whether we have reached the stage when we can be quite sure of results of input-output relationships arrived at in our studies.

For proper evaluation of input-output relationships we require first certain fundamental studies. For example, we must know exactly (*a*) how to evaluate family labour units and also (*b*) how to arrive at the exact number of farm family labour units that can be considered as necessary for the actual production examined. We may accept evaluation of family labour units at a certain fixed rate of wages but the second problem referred to is extremely difficult and requires much original research which has not been done so far. The labour units that we can accept as reasonably required for a certain production cannot be on basis of mechanistic tables prepared to show the average labour required for different operations. To accept such tables would be to forget that our farms are operated under extremely varying conditions and the labour units which are required for different operations cannot be held to be a fixed quantity (standardised). This is due to many reasons of course but chief among them is the varying managerial ability of the farm operator. The managerial ability of the farm operator varies to a much greater extent in India compared to U.S.A. or other countries. In the latter countries the difference between yield of the worst farm and the best farm is never so great as in India. Here one farmer may produce 10 times as much as another whereas in the advanced countries the difference may be just no more than twice or 100%.

Apart from the need for fundamental studies shown above, there is also the need for standardising methods of research used for determining input-output relationships. Even in the Farm Management Studies of the Research Programmes Committee of the Planning Commission, there have been certain divergences in the items considered for arriving at input-output relationships in the different States concerned. Due to this difficulty we often compare inputs and outputs which are really not comparable. It would be wrong to compare cost of production say in State A with that in State B if in the latter the item of Rent or Rental Value is dropped entirely. This serious defect persists right uptil to-day.

Leaving aside difficulties of character and technique which come in the way of a proper study of input-output relationships, we may now just glance at the results we can get in the different regions. To get an idea of regional differences in input-output relationships in India it would be best to compare the relationship between the value of all the inputs to that of total output in the different regions. In the Farm Management Studies we had four different concepts of total inputs (cost concepts) as follows:

COST A 1. This cost approximated actual expenditure incurred in cash and kind and included the following cost items : (*a*) hired human labour, (*b*) owned and hired bullock labour, (*c*) seed, (*d*) manures and fertilisers, (*e*) implement charges, (*f*) land revenue and other taxes, (*g*) irrigation charges. It did not include items like (*a*) Rent, (*b*) Interest on fixed capital and (*c*) Family human labour.

COST A 2. In the case of tenant cultivators we had to consider actual expenditure incurred in the form of rent paid. So we had this category which consisted of Cost A 1, *plus* actual rent paid.

COST B. This consisted of Cost A 1, *plus* (*a*) rent paid or (*b*) evaluated rental value of owned land and (*c*) interest on fixed capital (excluding land only).

COST C. This was Cost B *plus* the value of family human labour used.

It is worth recording that our investigation in the Economics of Farm Management in the two districts of the Deccan (in Bombay) revealed that the average total value of output per acre was less than total Cost C in Ahmednagar whereas it was a little more than such cost in Nasik. Table I will give a clear-cut idea of the differences in different regions of India in 1954-55. For inputs, we have considered all possible costs (Cost C).

TABLE I

Region 1	Value of total inputs per acre (Cost C) 2	Value of total output per acre 3	Difference 4
Bombay State			
Ahmednagar ..	37·38	28·50	(Sy) — 8·88
Nasik	49·75	52·29	(Sy) + 2·54
Madras	95·20	97·40	(C.A.) + 2·20
	88·40	70·40	(Sy) —18·00
West Bengal	198·00	215·50	(C.A.) +17·50
	184·30	173·60	(Sy) —10·70
Uttar Pradesh	203·97	264·11	(C.A.) +60·14
	217·07	262·88	(Sy) +45·81

It will be seen that except in Uttar Pradesh the value of output per acre was hardly enough to cover the value of total inputs. Could this be interpreted to mean that farming in all other regions was running in loss? This could be true if one could prove that the imputed values of the different factors of production were those which the farmer would get if he had not employed them in farming on his own farm (Opportunity Cost). This, however, is not possible for him to get. For example, if family labour is evaluated at the rate of the permanent farm servant's wage-rate the farmer would not get for hiring out his family labour any such wages.

It may be useful to note that the total input is made up of constituent items of very unequal importance. A break up of the total inputs in the Bombay-Deccan examined in the Farm Management Scheme in 1954-55 reveals the following significant facts.

TABLE II

Item	Percentages of total
1	2
(1) Human labour	36·60
(2) Bullock labour	28·70
(3) Rent and rental value of owned land ..	15·51
(4) Seed	6·36
(5) Implement charges	5·08
(6) Manures and fertilisers	4·16
(7) Interest on fixed capital	1·76
(8) Land revenue and other taxes	1·33
	100·00

It will be seen that human labour makes up the major part of total costs in agriculture (36.60%). This cost is not felt as any cash cost for reasons shown later. About 76.70% of the total human labour was actually supplied by the farmer and his family.

To judge the profitability of farming on the basis of cost which may not be looked upon as real costs by the farmer will not be very correct. For the farmer, those inputs are really very vital for which he has to pay or sacrifice something. For example, the farmer is not interested in the evaluated value of his family labour but is very keen on realising the value of labour hired by him or the money spent on seeds, manures, implements, etc. Normally it can be said that a farmer does not feel he is working at a loss so long as his output covers all inputs of A 2. The surplus obtained by deducting Cost A 2 from value of total output is known as Farm Business Income. This is the real measure of earnings of the farmer and his family for management, risk, labour and use of land and capital.

It follows from what has been said above that input-output relationships in Indian farming can be studied with a view to maximising farm business income. This can be done by maximising the value of output per acre and minimising Cost A 2. From this point of view, the following figures of Cost A 2 and value of output for different sizes of farms given in Table III, will be interesting.

It will be seen that in both the districts the value of output per acre was maximum in the smallest size of farms of 0–5 acres and decreased as the size of the farm increased. What are the factors which help in maximising output per acre in the small sized farms? From a statistical analysis of the relation between the value of output and individual input factors in production of important crops grown on the farms, we have observed that the value of output is related with

TABLE III

Size-group of Farms (acres)	Ahmednagar District			Nasik District		
	Cost A 2 per acre	Value of output per acre	Farm Business income per acre	Cost A 2 per acre	Value of output per acre	Farm Business income per acre
1	2	3	4	5	6	7
0— 5	68·89	119·84	50·95	73·42	112·71	39·29
5—10	41·30	72·31	31·01	57·82	95·95	38·13
10—15	31·03	53·92	22·89	33·92	64·85	30·93
15—20	29·87	41·36	11·49	36·75	68·61	31·86
20—25	18·47	25·60	7·13	27·08	51·26	24·18
25—30	20·19	33·88	13·69	35·24	73·28	38·04
30—50	24·71	34·84	10·13	32·23	60·69	28·46
50 and above ..	19·59	29·68	10·09	30·47	64·32	33·85
Over-all	24·62	37·81	13·19	35·43	67·17	31·74

human labour input and plough units (*i.e.*, human and bullock labour combined in the proportion of 1 : 2).

The relationship between the value of output per acre and human labour and plough units can be seen from the figures given in Table IV.

TABLE IV

Size-group of Farms (acres)	Ahmednagar District			Nasik District		
	Human labour units	Plough units*	Value of output	Human labour units	Plough units	Value of output
1	2	3	4	5	6	7
0— 5	36·95	16·75	119·84	16·53	16·42	112·71
5—10	19·77	11·27	72·31	13·78	12·43	95·95
10—15	15·80	10·30	53·92	7·86	7·93	64·85
15—20	10·78	10·38	41·36	9·42	10·28	68·61
20—25	5·29	6·58	25·60	2·83	10·44	51·26
25—30	7·31	7·65	33·88	7·99	8·38	73·28
30—50	7·86	8·47	34·84	7·80	7·71	60·69
50 and above ..	5·87	8·41	29·68	6·61	8·78	64·32
Over-all	8·91	8·82	37·81	8·08	9·09	67·17

1 Plough unit=Work of 1 man and 2 bullocks for 8 hours.

Though human labour and plough units are important production factors they are not the only factors of production.These factors together explain only about 40% of variation of output. The remaining unexplained variation may be due to differences in factors like fertility of soil, efficiency of labour, efficiency of management, etc.

The high value of output in the smaller (size) group of farms is also due to higher fertility of soils which can be seen from the figures given in Table V. The value of land and assessment per acre are good indicators of fertility of soil.

TABLE V—RELATION BETWEEN THE VALUE OF OUTPUT AND SOIL FERTILITY INDICATORS (VALUE OF LAND AND LAND ASSESSMENT)

Size-group (acres)	Ahmednagar District			Nasik District		
	Value of land per acre	Land Assessment per acre	Value of output per acre	Value of land per acre	Land Assessment per acre	Value of output per acre
1	2	3	4	5	6	7
0— 5	582	1·28	119·84	428	1·22	112·71
5—10	330	0·98	72·31	294	1·38	95·95
10—15	251	0·83	53·92	322	0·98	64·85
15—20	202	0·87	41·36	252	0·72	68·61
20—25	172	0·58	25·60	242	1·08	51·26
25—30	194	0·81	33·88	189	0·69	73·28
30—50	199	0·63	34·84	229	0·76	60·69
50 and above	212	0·64	29·68	254	0·98	64·32
Over-all	174	0·71	37·81	253	0·91	67·17

It will be seen from the above that the maximum value of land, maximum land assessment per acre and maximum value of output per acre go hand in hand and they have all been obtained in the smallest size-group of farms. This shows that higher fertility of soil on small farms is one of the factors contributing to higher yields. The fact that the soils in the small farms are better than the soils in bigger farms can also be inferred from the data given in Table VI.

It will be seen that the smallest sized farms (0–5) had the minimum percentage of light type of soil. Thus apart from the input factors of human and bullock labour, the intrinsic soil fertility of the farm also helps in maximising output in the smallest sized farms.

TABLE VI—PROPORTION OF SOIL TYPES ON DIFFERENT SIZE OF FARMS

Size-group (acres)	Ahmednagar District			Nasik District		
	Light	Medium	Deep	Light	Medium	Deep
1	2	3	4	5	6	7
0— 5	27·75	70·37	1·88	22·25	59·68	18·07
5—10	40·93	43·68	15·59	43·10	48·89	8·01
10—15	30·90	61·86	7·24	47·76	47·56	4·68
15—20	27·65	54·65	17·70	46·82	48·98	4·20
20—25	45·16	47·35	7·49	35·68	63·80	0·52
25— 30	27·76	58·37	18·87	54·07	45·26	0·68
30—50	39·70	42·06	18·34	47·07	47·72	5·21
50 and above	34·65	46·16	19·19	34·45	62·08	3·47
Over-all	35·87	47·97	16·16	42·80	52·60	4·60

The increase in production is also possible by more use of manures and fertilisers which can be seen from the following figures.

TABLE VII—UTILISATION OF MANURES AND FERTILISERS AND VALUE OF OUTPUT PER ACRE

Size-group of Farms (acres)	Value of manure and fertilisers used	Value of output per acre
1	2	3
0— 5	13·04	119·84
5—10	6·59	72·31
10—15	4·34	53·92
15—20	4·98	41·36
20—25	1·45	25·60
25—30	1·55	33·88
30—50	3·47	34·84
50 and above	2·34	29·68
Over-all	3·14	37·81

It will be seen that the higher use of manures and fertilisers on the smaller farms had resulted in increased production.

Though the value of output per acre in the smallest sized farms is high, Cost A 2 per acre is also high with the result that farm business income per acre is not very different from that in other size-groups of farms. This is evident from the figures of Nasik district. Why should Cost A 2 be so high in small sized farms? Can this cost be not reduced to increase farm business income?

The detailed break-up of Cost A 2 per acre in the smallest sized farms (5-10 acres) was as under.

TABLE VIII

Item	Ahmednagar	Nasik
1	2	3
(1) Hired human labour ..	7·61	5·20
(2) Bullock labour	32·11	39·09
(3) Seed	5·58	8·40
(4) Manures and fertilisers ..	13·04	8·83
(5) Implement charges ..	7·86	8·10
(6) Land revenue and cesses ..	1·28	1·22
(7) Miscellaneous	1·41	0·91
	68·89	71·83

It will be seen that about half of the total Cost A 2 was spent on bullock labour. All this bullock labour is obtained from farm bullocks. As these bullocks are required to be fed irrespective of whether they are used on the farm or not, the cost on account of bullock labour becomes more or less a fixed cost. If this cost can be spread out either by increasing the size of the farm or by increasing the production on the same farm by intensive methods, it is possible to minimise this cost and eventually increase farm business income.

In conclusion, we can say that the study of input-output relationship in Indian Agriculture should be made with a view to increasing farm business income. For this, efforts should be made to increase production. This can be done by more use of manures and fertilisers and more use of human and bullock labour in productive operations like irrigation (well irrigation) and preparatory tillage. As human and bullock labour are available almost "free" to the farmer, they can be used in the intensive methods of production.