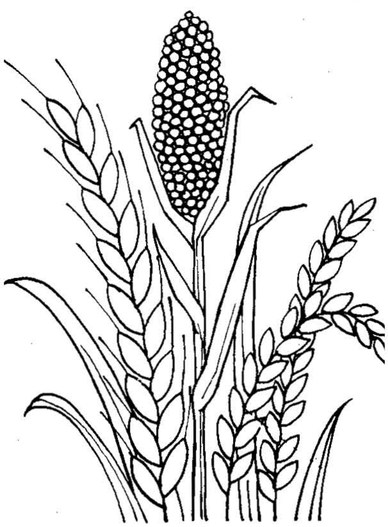
Vol XXVII
No. 1

JANUARY-
MARCH
1972

ISSN 0019-5014

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS



INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

MACRO CONSTRAINTS ON AGRICULTURAL DEVELOPMENT IN INDIA

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Recent break-throughs of high-yielding crop varieties, and the initial success of the new agricultural development strategy, have combined to provoke a new optimism on the agricultural development of India. Warnings have, however, already been voiced as to the possible social and political repercussions that could follow if the new development is allowed to proceed in a spotty and lopsided way: leaving some segments of society out of the new development for the time being could in fact make their lot worse rather than better.[1] In addition to these concerns it is also necessary to discuss the alternatives as regards capital intensity versus labour intensity, and generally the relation between micro and macro development.

Development techniques which have proved eminently successful on a local level or in limited sections of the country are not necessarily applicable on the scale of the whole country. The foremost difference lies in what may be termed the "quantity problem." To understand some of the macro-economic constraints with which Indian agricultural development "across the board" has to contend, we should examine, first, some relevant theoretical and historical statements, and thereafter some of the facts of the Indian economy.

SECTOR PROPORTIONS, FACTOR SUPPLIES, AND SECTOR INTERACTIONS

Agricultural expansion may be obtained, except by the necessary use of more high-yielding varieties of leading crops, both by the application of more capital (resources generated outside the agricultural industry—"external factors"), and by more intensive use of labour and land. A wide array of possible combinations of these principal paths represents the field within which the choice of strategies must be made.

An economy in the early stages of modern development and still living with a very low level of per capita income has, by definition, severe shortage of nearly all resources other than low-skilled labour. A development strategy which aims at increasing the use of all kinds of inputs at a time risks very much to become less than optimal in its husbanding with scarce resources. A selective strategy is more likely to make the most of what the country has.

There is a complaint of long standing—in most countries, indeed—that agriculture does not seem to have access to enough externally generated means of production. Restrictive credit policy is often blamed, especially when agri-

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1. Thus C. R. Wharton, Jr., "The Green Revolution: Cornucopia or Pandora's Box?," *Foreign Affairs*, Vol. 47, No. 3, April, 1969, pp. 464-476.

cultural machinery industries (for instance) also complain of lack of market expansion for their products (as in the United States in the 1920s).

In a general way, many macro-economists have since long understood that the supply of external factors to agriculture is constrained by the existing sector proportions: this supply will become larger (in relation to the absolute size of the agricultural industry), the smaller the relative size of the agricultural industry (the smaller its share in the total economy). This constraint has recently become somewhat more articulate through the discovery of the Simantov constants.[2] Briefly, historical evidence suggests that agriculture's external inputs tend to be on the magnitude of 3 per cent of the national product, independently of time, place, and level of per capita income; and the post-farm part of the food-agribusiness complex (food processing and marketing) tends to be of the magnitude of 8—9 per cent of the national product, also independently of time, place, and level of per capita income.

A partial confirmation of the latter of these constants was provided in an article by Chenery and Taylor,[3] showing, among other things, that the food processing industries tend to occupy a constant share in the national product.

Both of the Simantov constants were tested for consistency with independent economic data by Dovring.[4] The results were related to per capita supply of food (consumer cost level), at several per capita income levels ranging from very low to fairly high. Assuming empirically given typical sector proportions at these various income levels, it was found that application of the Simantov constants is consistent with demand figures derived from comparative analyses of household consumer surveys (also on the consumer cost level). Only at very high income levels do the two sets of figures (supply and demand of food) cease to be consistent, indicating the likelihood that the Simantov constants are not applicable at such income levels (from which very little empirical material has been available so far). Some selected figures are shown in Table I.[5]

From this test one may conclude that the Simantov constants can be safely applied as indicators of a major constraint in the build-up of capital intensive agriculture, at low and medium levels of per capita income. Rates of expansion much higher than those usually experienced in countries at such income levels would normally be ruled out. Before using these data derived from past experience in discussing future strategies of development, we should

2. A. Simantov, "The Dynamics of Growth and Agriculture," *Zeitschrift fur Nationalokonomie*, Vol. 27, No. 3, 1967, pp. 328-351.
3. H. B. Chenery and L. Taylor, "Development Patterns: Among Countries and Over Time," *The Review of Economics and Statistics*, Vol. 50, No. 4, November, 1968, pp. 391-416, the diagram referred to here on p. 410.
4. F. Dovring : Income Growth Rate and Sector Proportions: The Share of Agriculture at Successive Levels of Income, University of Illinois, Department of Agricultural Economics, AERR 97, December, 1968 (mimeo.).
5. *ibid.*, p. 5, Table 2.

TABLE I—THEORETICALLY CALCULATED AGRICULTURAL PRODUCT AND PRODUCTION, AND AGGREGATE FOOD SUPPLY, AT SELECTED LEVELS OF PER CAPITA DOMESTIC PRODUCT (1960 DOLLARS)

Levels of per capita GDP	Per cent of GDP generated in agriculture	Agricultural product per capita of whole population	Col. (3) plus 3 per cent of GDP	Col (4) minus 10 per cent*	Col. (5) plus 9 per cent of GDP per capita food supply	Food spending**
(1)	(2)	(3)	(4)	(5)	(6)	(7)
50	50	25	26·5	23·85	28·35	30
100	42·4	42·4	45·4	40·86	49·86	50
200	33·7	67·4	73·4	66·06	84·06	80
400	23·6	94·4	106·4	95·76	131·76	125
800	13·2	105·6	129·6	116·64	188·64	190
1,600	6·7	107·2	155·2	139·68	283·68	270
3,200	3·4	108·8	204·8	184·32	472·32	370

* Ten per cent represents an approximation of the share of non-food products in agricultural production (world-wide).

** The rounded figures for per capita food spending in column 7 are derived from consumer survey data as published in The State of Food and Agriculture 1957, Food and Agriculture Organization of the United Nations, Rome, 1957 ; they are crudely consistent with the sequence of demand elasticities from 0·75 at the lower to 0·40 at the upper end of the scale. Note that these elasticities refer to levels of consumer spending, not of per capita GDP.

also test them in a way that shows the consequence of disregarding them. What would be the consequence of applying significantly larger portions of a developing nation's resources to building up the food part of the agribusiness complex ?

A starting point may be taken in the figures shown in the last two columns of Table I. These figures show the harmony between (per capita) income-related demand and supply functions for food which is obtained when the Simantov constants are applied to typical income level sector proportions. From the demand function for food (the Engel curve) one may also compute the overall, society-wide (private and public) demand function for other goods and services (including investment) by subtracting the food amounts from the amounts of per capita national product. Some resulting figures are shown in Table II.

The agreement between columns 6 and 9 is a consequence of the premises used. In a normal case, the equilibrium around the Engel curve thus calls for a characteristic proportion between the rates of growth of food and non-food demand, rather independently of the general growth rate. This proportion is rising with rising income levels, slowly at first and more rapidly on higher income level (extrapolation would show it approaching infinity when the growth rate of food demand approaches zero). On low levels of per capita

TABLE II—THEORETICALLY CALCULATED AMOUNTS OF PER CAPITA FOOD AND NON-FOOD DEMAND (CONSUMER AND NON-CONSUMER DEMAND) AT SELECTED LEVELS OF PER CAPITA DOMESTIC PRODUCT (IN 1960 DOLLARS) AND THEIR RELATIVE GROWTH RATES

			At a general per capita GDP growth rate of 2 per cent per year			At a general per capita GDP growth rate of 3½ per cent per year		
Levels of per capita GDP	Food spending	Non-food spending	Food demand growth rate	Non-food demand growth rate	Ratio Col. (5)/ Col. (4)	Food demand growth rate	Non-food demand growth rate	Ratio Col. (8)/ Col. (9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
50	30	20						
100	50	50	1·47	2·64	1·80	2·58	4·68	1·81
200	80	120	1·34	2·53	1·89	2·38	4·47	1·88
400	125	275	1·27	2·39	1·88	2·25	4·23	1·88
800	190	610	1·19	2·29	1·92	2·11	4·06	1·92
1,600	270	1,330	1·00	2·24	2·24	1·76	3·97	2·26

income, this ratio changes slowly; the first three entries would form a series of 1.84, 1.86, 1.88, if only food spending at 100 dollars income were modified to $49.80 instead of $50 as in the table. Such details only strengthens our confidence in the validity of the main finding.

This constancy in the proportions between the growth of food and non-food demand is apparently a reflection of the relative income-demand elasticities of these two main groups of products, and it is also apparently this constancy which determines the constancy of the Simantov constants. The relative positions of agricultural output and value product decline, but not enough to allow the pre-and post-farm parts of the food-agribusiness aggregate to rise; but still enough to prevent them from declining. The relationship is not merely historical—it also agrees with cross-section data, recent in time.

Now it can be shown that, if the rate of application of external factors as inputs to agriculture is stepped up by only two or three percentage points of the national product, the supply proportions just discussed will be quite significantly altered. Let us first consider the supply proportions to final demand that would come about. Some examples are shown in Table III.

TABLE III—PER CAPITA SUPPLY OF GOODS FOR FINAL USE, AS FOOD AND NON-FOOD, IF USE OF EXTERNAL FACTORS AS PRODUCTION INPUTS INTO AGRICULTURE IS INCREASED BY 2 OR BY 3 PER CENT OF THE NATIONAL PRODUCT, AT ALTERNATIVE LEVELS OF PER CAPITA INCOMES (1960 DOLLARS)

	Per capita supply, when external inputs to agriculture is increased to					
	5 per cent of national product			6 per cent of national product		
Income level	Food	Non-food	Non-food as per cent of normal demand	Food	Non-food	Non-food as per cent of normal demand
50	31	19	95·0	31·5	18·5	92·5
100	52	48	96·0	53	47	94·0
200	84	116	96·7	86	114	95·0
400	133	267	97·0	137	263	95·6
800	206	594	97·4	214	596	96·1
1,600	302	1,298	97·6	318	1,282	96·4

It is evident that already a 5 per cent, and even more a 6 per cent, rate of external inputs into agriculture would displace both the Engel curve and its counterpart of the supply of non-food goods, substantially away from their empirically given paths. It is also interesting to note that such a deviation would be proportionately largest at the lowest level of per capita income, while at higher income levels the smaller relative size of the food sector gives more leeway for variation.

In Table III, the rate of external inputs had been changed once and for all, to a constant higher level. Even more striking is the impact, however, of allowing this rate of rise over a period of time, *e.g.*, over a period when per capita income doubles. Table IV shows this under two alternative assumptions, that it occurs when per capita income rises from $50 to $100, or from $100 to $200. These are the two income level intervals within which the Indian economy will move within its medium-term future.

The lowering of the growth rate proportions, from 1.85—1.9 down to 1.6 or 1.5 would undoubtedly mean great distortions in the demand-supply relationships. In a market economy, the penalties for thus violating the demand patterns are severe and well-known: falling terms of trade for the industry that is over-expanding and shortages in other sectors with price inflation as a consequence. When things are left to themselves, both of these consequences would soon enough force the volume of agriculture's external inputs back to the proportions they obeyed before. The only way in which a market economy could obviate these consequences would be by reducing non-consumer spending, *i.e.*, above all capital formation—and this consequence is the last that the Indian economy would wish to accept. Only in an iron-clad command eco-

TABLE IV—RELATIONSHIPS AS IN TABLE II, WITH AGRICULTURE'S EXTERNAL INPUTS STEPPED UP TO 5 PER CENT AND TO 6 PER CENT RESPECTIVELY, OF THE DOMESTIC PRODUCT, OVER DOUBLING PERIOD

	Per capita supply				Annual rates of increase, when per capita product grows at					
	at 5 per cent external inputs		at 6 per cent external inputs		2 per cent			3½ per cent		
Income level	Food	Non-food	Food	Non-food	Food	Non-food	Ratio	Food	Non-food	Ratio
(*a*) Starting at normal proportions at the $50 per capita income level										
50	30	20	30	20						
					1·58	2·50	1·58	2·78	4·47	1·61
					1·63	2·47	1·52	2·88	4·36	1·51
100	52	48	53	47						

Note : The second line of numbers in the right hand columns represents the six per cent alternative in the left hand columns.

(*b*) Starting from normal proportions at $100 per capita domestic product										
100	50	50	50	50						
					1·49	2·43	1·63	2·62	4·29	1·61
					1·56	2·38	1·53	2·74	4·20	1·53
200	84	116	86	114						

nomy would it be possible to violate the invariances embodied in the Simantov constants, as actually happened, *e.g.*, in the USSR over a long period; but even a command economy is far from immune to the distortive effects of over-investing in a farm sector already burdened with huge amounts of labour having only farm skills and not in demand in other sectors.[6]

Thus the Simantov constants reflect the level of use of non-agricultural resources to serve the food complex of the economy which are consistent with the empirically given demand functions for food and for other goods—the Engel curve and its counterpart. These demand functions appear to be, with slight variations, the same the world over.[7] In individual countries the Simantov constants may be modified slightly to one side or the other, but no drastic variation is to be expected.

In a concerted development effort it may prove possible to hold down consumer spending as a whole, to a lower level than would occur spontane-

6. On Soviet agriculture and its input situation, see F. Dovring, "Soviet Farm Mechanization in Perspective," *Slavic Review,* Vol. 25, No. 2, June, 1966, pp. 287-302, and *idem,* "Progress in Mechanization of Soviet Agriculture," in The Soviet Rural Community, edited by J. R. Millar, Urbana, Illinois, U.S.A., 1971, pp. 259-275. See also, *e.g.*, *idem,* Land Reform in Hungary, Washington, D.C., 1970, pp. 36-41, and *idem,* Land Reform in Yugoslavia, Washington, D.C., 1970, pp. 37-46.

7. See The State of Food and Agriculture 1957, Food and Agriculture Organization of the United Nations, Rome, 1957, pp. 77 spp., diagram on p. 79.

ously, and thus to step up the rate of savings and capital formation somewhat. But this can only be done to step up investment in infra-structure and in basic industries. It cannot for any great length of time be done to increase the rate at which external inputs are used in a consumer goods industry such as agriculture. Beyond the point where current food demand is met without rationing, the demand function for food, expressed in the Engel curve and reflected in the Simantov constants, will deter any rise in the rate of use of external resources in agriculture. Over-investment in food farming would not only backfire because it would violate current demand functions; it would also, by channelling more scarce resouces to the food sector, undercut and slow down the build-up of productive and employment capacity in other sectors—a build-up which is an indispensable requisite for continued development on the whole, including the expansion of the markets for food without which agriculture cannot go on developing.

We may now turn to examining some of the macro-economic data of the Indian economy.

MAJOR INPUTS IN INDIAN AGRICULTURE AND RELATED MACRO DATA[8]

Net domestic product data from recent years are shown in Table V.

TABLE V—NET DOMESTIC PRODUCT OF INDIA 1960-61—1967-68 (FISCAL YEARS BEGINNING APRIL 1)

(in thousand million rupees)

	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68
A. Current prices								
1. Agriculture ..	65·7	67·7	69·1	80·2	98·5	94·4	113·0	144·8
2. Forestry and logging	1·7	2·0	2·1	2·5	2·6	2·9	3·2	3·4
3. Fishing	0·8	0·9	0·9	0·9	1·1	1·2	1·4	1·5
Sub-total 1-3	68·2	70·5	72·0	83·6	102·1	98·5	117·6	149·7
Mining, manufacturing, construction and utilities	26·9	29·3	32·1	37·1	40·9	44·3	48·3	51·1
Transport and trade ..	18·8	20·4	22·3	25·1	29·5	31·9	36·9	41·2
Services	19·9	21·5	23·7	26·6	29·9	33·8	37·6	39·8
Total	133.8	141·6	150·0	172·3	202·3	207·5	239·0	281·9
B. 1960-61 prices								
1. Agriculture	65·7	66·3	64·4	66·1	72·3	61·1	61·0	72·5
2. Forestry, etc. ..	1·7	1·8	1·9	2·1	2·0	2·2	2·2	2·2
3. Fishing	0·8	0·8	0·8	0·8	0·9	0·9	0·9	0·9
Sub-total 1-3	68·2	68·9	67·0	69·0	75·2	64·2	64·1	75·6
Mining, manufacturing, construction and utilities	26·9	28·9	31·0	34·0	35·9	36·5	36·7	36·9
Transport and trade ..	18·8	20·1	21·3	23·0	24·3	24·9	25·3	26·1
Services	19·9	21·1	22·5	24·1	25·5	26·5	27·3	28·3
Total	133·8	138·9	141·8	150·0	160·9	152·0	153·3	166·9

* Provisional data.

Source : Statistical Abstract of the Indian Union, 1968, Central Statistical Organisation, Government of India, pp. 469-470.

8. In assembling the data used in this section, the author was assisted by Mr. Warwick Papst.

In recent years, agriculture in India has produced close to half the domestic product, in current terms. Comparison with the data in constant prices shows this to be in part due to a price reaction following upon the bad harvests reflected in the low constant price figures for agriculture's factor income in 1965-66 and 1966-67. From nearly 50 per cent in 1960-61, the agricultural share fell to 46 per cent in 1964-65, then to 40 per cent in 1966-67, recovering to 43 per cent in 1967-68, indicating some modest degree of sector differentiation. The manufacturing sector, the leading one for sector differentiation, grew by more than 5 per cent over the years shown in the table, and so did the entire non-agricultural part of the economy.

With the much better harvests since 1967-68, the growth rate of agriculture has again been stepped up, even though it is as yet difficult to discern what higher rate of medium-term growth may have become stabilized. Price reductions, which will logically follow upon the sharply increased factor productivities through the use of high-yielding crop varieties will, of course, again bring down the apparent (absolute and relative, current price) size of the agricultural sector. The same price movement should act as a powerful stimulus to the non-agricultural part of the economy. At the same time these price changes will necessitate readjustments within the farm sector—readjustments which may prove complicated and difficult to achieve.

How does the previously sluggish and the recently stepped up rate of growth in India's agriculture relate to the supply of factors, particularly the external ones? Information is far from consistent or easy to interpret. As a first leading, let us turn to the input-output table of 1963.[9] Current inputs into agriculture, of non-agricultural origin, are listed as follows :

	(million rupees)
Chemicals	80·6
Petroleum products	301·2
Metal products	689·6
Fertilizers	573·6
Electricity (for irrigation)	88·6
Total of above	1,733·0

There is also an entry of Rs. 269.2 million for wood products (repair and depreciation of carts), but these we may treat as coming from the rural economy and thus unrelated to factor scarcities in the non-agricultural sector. Items of transport and trade in this input-output table do not belong in the

9. P. N. Mathur, *et. al.*, "Input-Output Flow Table (32 × 32) 1963 (at Purchasers' Prices)," *Artha Vijnana*, Vol. 11, No. 2, June, 1969, pp. 181-199.

present analysis because they contribute to the final output "at purchasers' prices," thus they are inputs into food distribution but not into agriculture. Transport and trade costs relating to agriculture's external inputs are included in the figures shown above.

Comparing the total of these external costs with the domestic product data in Table V, we find that these external inputs in 1963 represent merely 1 per cent of India's net domestic product in 1963-64 (in current prices). Judging from this, agriculture would, at that time, have been badly starved of external inputs.

The data are not very strong. The weakest part is in the largest group, "metal products," which is simply taken as one-tenth of the stock of metal machines (above all pumps for irrigation), assuming this fraction to represent depreciation and repair costs for the year.

The next largest item, fertilizers, is somewhat better. Compiling detailed data for a series of years, with specifications of the three main categories of fertilizers and using the prices of the predominant kinds, one arrives at a sum of close to Rs. 900 million for 1963-64.[10] If anything, then, the figure in the input-output table may be on the low side, but this alone would not do much to change the finding of a low level of external inputs in Indian agriculture in the early 'sixties.

The total shown, however, relates only to current inputs. Investment is shown rather incompletely in the input-output table: partly in a single final use column for capital formation without any detail as to receiving industries (but this column explicitly relates only to manufacturing industries anyway); partly in the column for government as a final user (this is especially evident in the construction line, where government receives two-thirds of gross output and most industries nothing); and finally to some extent it is buried in the consumption column (again the construction line illustrates this).

Now it must be said that the Simantov constants were discovered in such a way that they ought to reflect only current costs, not capital formation: they represent, basically, the difference between gross product (or, net output) and value added of agriculture. At the same time, these constants were derived also from countries in which the build-up of capital in agriculture has been relatively slow and even, with relatively small annual differences between gross investment and annual charges of depreciation and upkeep. Economic logic tells us that the macro-constraint upon expanding external inputs into agriculture must reckon also with net investment, if that tends to be large. We should thus try to gauge the annual costs of acquisition of capital by and/or for agriculture.

10. See Table VI.

The chief source of information is in the planning texts. Again this differs from the accounting procedures in the countries from which the Simantov constants were derived, since these never include public sector outlays in their accounts of agriculture's assets and expenditures. But again, the public sector contributions are relatively so large in India that these figures must, in some way, be considered here.

The Third Five-Year Plan (1961-66), and the Draft of the Fourth Plan (1969-74) wanted to allocate the following amounts (of public and private expenditures) to agricultural development (for five-year periods).[11]

(million rupees)

Items	Third Plan	Draft Fourth Plan
1. Irrigation : minor	1,768	2,700
2. Irrigation : major and medium	5,993	5,802
3. Agricultural production	2,261	2,038
4. Community development, agricultural programmes	1,260	2,880
5. Co-operation	801	760
6. Soil conservation	727	770
Total	12,810	14,950
Sub-total, excluding items 3 and 5	9,748	12,152

Of the amounts shown, "agricultural production" in part overlaps with items already shown as current inputs, and in part it includes public administration outlays which should be treated as public sector entries in national accounts. The item for "Co-operation" is also not necessarily to be included among agriculture's production inputs. The sub-totals, without these two items, comes to 1.1 and 14 per cent, respectively of India's domestic product in the five-year periods concerned.

The Third Plan was not quite fulfilled. The actual amounts spent were smaller than those planned. No matter how the evidence is turned around, it is clear that the total of non-agricultural resources used in agriculture as both investment and current production inputs was rather less than 3 per cent of India's domestic product in the years of the Third Plan.[12]

The above would explain why agriculture was for a long time India's lagging sector.

Attempting to use the input-output table to derive the second Simantov constant (the share of food processing and distribution), one finds only 4½

11. Towards a Self-reliant Economy, Delhi, 1961, p. 175; Fourth Five-Year Plan 1969-74—Draft, Planning Commission, Government of India, Delhi, 1969, p. 139.

12. The somewhat higher level of external costs foreseen in the Fourth Five-Year Plan 1969-74—Draft, *op. cit.*, p. 139. implies only a modest rise in agriculture's share of external resources.

per cent of the domestic product in these activities. However, the uncertainties are here even greater than in other parts of the table, especially in the trade row which is residual and includes all the errors in the other rows. Hardly any use can therefore be made of this estimate.

We will now try to pursue the main groups of external inputs to agriculture into the medium-term future. Vigorous new trends appear to have started recently.

(*a*) *Fertilizers*

Consumption of fertilizers in India is summarised in Table VI.

TABLE VI—CONSUMPTION OF FERTILIZERS IN INDIA, AND ESTIMATE OF COST

(Thousands of metric tons, pure content; millions of rupees, constant prices)
Price weights used: N 1700, P_2O_5 1400, K_2O 500 rupees per ton of nutrient

	1952-53-1956-57	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
N	123	329	429	538	541	830	1,135	1,222	1,244
P_2O_5	18	87	130	148	134	275	438	296	315
K_2O	8	43	49	63	90	134	206	164	137
Total nutrients	148	458	609	749	765	1,238	1,780	1,682	1,696
Price weighted N ..	209	559	730	915	919	1,411	1,931	2,077	2,115
P_2O_5	25	121	182	207	188	384	613	414	441
K_2O	4	21	25	31	45	67	103	82	69
Total ..	238	701	937	1,153	1,152	1,862	2,647	2,573	2,625

Source : Fertilizers—An Annual Review of World Production, Consumption, Trade and Prices 1969, F.A.O., Rome, 1970. *Cf.* also Production and Consumption of Fertilizers—Annual Reviews 1969-70, The Fertilizer Association of India, New Delhi, April, 1970, especially pp. 33, 38, 41.

Consumption has thus tripled in the six years since the 1963 input-output table. The figures for the last three years indicate about 1 per cent of the domestic product of India in those years, for fertilizers alone.

(*b*) *Pumps and Other Machines*

The input-output entry in regard to metal machines may be understood to represent chiefly pump-sets. Tractors in Indian agriculture were reported as 8,000 in 1948-52, 21,000 in 1952-56, and 54,000 in 1966—rapid enough growth in relative terms but as yet a very small element in the tractive power of Indian agriculture.[13]

Pump-sets were reported to be over half a million "energized" units (*i.e.*, driven by electricity) at the end of 1965-66, and over 650 thousand a year later; plans for 1967-68 and 1968-69 should have brought it to 1.1 million by now, and the Fourth Plan (for 1969-70 through 1973-74) envisages "energizing" another 1.4 million, for a 1974 total of $2\frac{1}{2}$ million, or five times the 1966

13. F.A.O. Production Yearbook 1968, p. 477.

actual,[14] which in turn must have been larger than the 1963 figure on which the input-output table based its estimate for annual depreciation and repair charge.

Manufacturing data from recent years indicate domestic production of pump-sets as 104 thousand in 1960 and 312 thousand in 1967,[15] thus annual increments of ¼ million are well within the industrial capacity of the country.

By these indications, the annual depreciation and repair charge by 1970 should be at least twice the 1963 amount, or Rs. 1,400 million, while plan fulfilment by the mid-'seventies would raise it to at least five times that of 1963, or to Rs. 3,500 million. In neither case is any allowance made for the net investment in increased pump numbers.

(*c*) *Electricity*

The amount given in the input-output table appears consistent with other data. Table VII shows data on electric power for some recent years and a five-year projection.

TABLE VII—ELECTRIC POWER CONSUMPTION IN INDIA

(*in million kWh*)

Year	Total	Thereof for agricultural pumping	Equals per cent of total	Agriculture's share (million rupees)*
1961-62	16,449	991	6·0	73·3
1962-63	18,682	1,104	5·9	81·7
1963-64	21,406	1,153	5·4	85·3
1964-65	24,219	1,397	5·8	103·4
1965-66	26,735	1,892	7·1	140·0
1966-67	29,096	2,090	7·2	154·7
1973-74 (projection) ..	91,220	8,140	8·9	602·4

* See text, below.
Sources: India, Central Electric Authority, Annual Electric Power Survey of India, 3, 1965 p. 44; *ibid.*, 5, 1968, p. 46.

The percentage of power consumed in agriculture according to the input-output table for 1963 (in value terms) is 5.3 per cent; the above figure of 5.4 per cent (in kWh terms) is quite close. This confirms the information in another source which shows that agricultural uses pay the average price for power—in between industrial uses which are subsidized and the domestic and commercial lighting sub-sector which is taxed. In more recent years, agriculture has paid somewhat more than the average price, but still far below the domestic use price.[16]

14. Fifth Annual Electric Power Survey of India (Central Electric Authority), 1968, p. 49.
15. Statistical Abstract of the Indian Union 1967, Central Statistical Organisation, Government of India, p. 130.
16. Public Electricity Supply—All-India Statistics, Annual; Government of India, Ministry of Power, Central Water and Power Commission.

Applying a constant price of 7.4 paise per kilowatt hour, as in 1962-63 according to the last quoted source, we obtain the outlays shown in the last column of the table. Apparently the use of electric power for agricultural pumping is and will continue to be a cost item of modest size, even though the use of electricity may be rising faster than the number of pump-sets (partly through displacement of petroleum fuel).

(*d*) *Motor Fuel*

The entry for petroleum fuel in the 1963 input-output table was some Rs. 300 million, or about 6 per cent of the total petroleum fuel consumption (of which nearly one-third was from import sources). Much of this motor fuel in agriculture went to oil-fueled pump-sets and this item should thus be superseded by electricity as motive power in the next few years.

In physical quantity, Indian petroleum products consumption in 1963 was 7.5 million tons.[17] Six per cent of this indicates 460 thousand tons in agriculture, assuming that agriculture paid the average price.

(*e*) *Chemicals*

The figure for agricultural chemicals in the input-output table is estimated as being in a certain proportion to the fertilizer expenditures. The small amount is thus a rather weak figure. Later statistics[18] show that since 1963, the use of agriculture chemicals has increased vigorously. A few items, such as DDT and copper compounds, have stabilized, but most have been increased many times over. It is therefore not unreasonable to assume the trend to have been roughly parallel to that of the fertilizers. Expenditures for agricultural chemicals in the late 'sixties and in 1970 may therefore have been of the order of Rs. 250-300 million a year, or on the magnitude of one-tenth of 1 per cent of the national product.

FORWARD PROJECTIONS

The consequences of alternative paths of development policy in Indian agriculture can be sketched on the basis of extrapolations of known trends, and with alternative assumptions as to possible changes of trend. Some perspective can be obtained also from comparisons with other large countries. Projections will be tried here for a long-term period of 15 years and for a very long-term one of 30 years. The exercise is done for the purpose of illustration; no "predictions" are intended.

Population may be projected on the basis of a constant growth rate of 2 per cent (a little below the most recent trend), or on the assumption of some

17. Statistical Abstract of the Indian Union 1967, *op. cit.*, p. 126; *cf.* United Nations Statistical Yearbook 1967, p. 287, with 7·5 million tons.
18. F.A.O. Production Yearbook 1968, pp. 491-528.

deceleration in the demographic growth rate. Starting from an estimated 1970 population of 550 million, the 2 per cent growth rate will yield a population of 740 million in 1985 and about a billion in the year 2000. If the population growth rate is assumed to decelerate in such a way that the compound rate over 30 years comes down to 1 per cent per year, then the 740 million figure would obtain in the year 2000; of intervening growth, most would occur in the first decade, some in the second, and very little in the third decade.

Projections of national product may also be made under alternative assumptions which may include a constant rate or an accelerating one. Assuming extrapolation of recent trends, a constant rate would have to be no more than 4 per cent per year. This would cause national product to multiply by 1.8 in 15 years and by 3.2 in 30 years. With a concomitant rise in population on the magnitude of 2 per cent per year, per capita product would rise merely by 35 per cent in 15 years and by 80 per cent in 30 years; decelerating demographic growth might raise the 30-year result to an increase by 2½ times. With a starting level in 1970 in the vicinity of $70 per capita (1960 prices), such low rates of long-term increase would be quite discouraging and are probably unnecessarily pessimistic. Better performance should be both required and expected in the decades ahead.

Assuming some higher, yet constant rate of growth is rather arbitrary; there is no particular reason to expect the growth rate over a few years to rise sharply over its recent level and then stay on that improved level. To visualize what may become possible, we are therefore projecting two alternative paths of accelerating growth rates : one by which the growth rate would gradually rise from 4 per cent in 1971 to 8 per cent in 2000, and another by which it would similarly rise from 5 to 10 per cent per year. In both cases, the acceleration factor would be 2⅓ per cent per year. Consequences for five-year periods are shown in Table VIII.

TABLE VIII—PROJECTIONS OF NATIONAL PRODUCT GROWTH PROPORTIONS UNDER ALTERNATIVE ASSUMPTIONS AS TO GROWTH RATES

Year	Growth at 6 per cent per year	Growth accelerating from 4 to 8 per cent in 30 years		Growth accelerating from 5 to 10 per cent in 30 years	
	Amount	Rate	Amount	Rate	Amount
0	1	4	1	5	1
5	1·34	4·49	1·23	5·61	1·30
10	1·79	5·04	1·56	6·30	1·74
15	2·40	5·66	2·03	7·07	2·41
20	3·21	6·35	2·73	7·94	3·47
25	4·29	7·13	3·79	8·92	5·23
30	5·74	8·01	5·48	10·01	8·26

Acceleration from 4 to 8 per cent would increase the national product over 30 years by nearly as much as would a steady rate of 6 per cent, but the results in early parts of the period would be notably lower.

With population growing at 2 per cent per year, per capita income would be about 3 times the starting level, at the end of 30 years, and $1\frac{1}{2}$—$1\frac{3}{4}$ times in 15 years. With a starting level of $70, it would rise to $105-125 in 15 years and about $210 in 30 years.

The higher rate, accelerating from 5 to 10 per cent, would yield the same result as the 6 per cent steady rate in 15 years, but would more than 8-fold the total in 30 years, hence raise per capita income at that time to 4.6 times the starting, hence to more than $320.

Assuming decelerating population increase, as indicated above, would considerably improve the positions, if mainly in the very long run. With average growth of population at 1 per cent (compound rate), average per capita income could climb to 4 to 6 times present level ($280 to $420) in the year 2000. Only the last-mentioned case, implying an extreme combination of favourable circumstances, would entail accelerating structural change.

In this extreme case, the agricultural population could be down to about one-third of the total (of 740 million), thus a substantially smaller figure than at present but still an enormously high density of people on the land. With any less favourable combination, either in income growth rate or in population growth rate or both, agricultural population in the year 2000 will still be as large as at present or larger. With the slower acceleration of income and the deceleration of population growth, agricultural population in the year 2000 would still be at least 40 per cent of the total or some 300 million—the same as at present.

The alternative projections span the range of the possible, it seems to us. For the decade of the 1980s, we should expect per capita income to be in the range of $100—$200, while at the turn of the century, it could be anywhere between $200—$500 (all this is 1960 prices). Wide as these margins are, they are far from being without value as orientation for the paths of development which are feasible as against some which may not be feasible at all. In neither case can we expect Indian agriculture around the year 2000 to be highly capitalized and mechanized.

To illustrate what would be involved, let us compare India with two large countries which have achieved a highly capitalized and mechanized agriculture. Figures for the United States, the Soviet Union, and India are shown in Table IX.

TABLE IX—SELECTED DATA ON AGRICULTURE IN THE UNITED STATES, THE SOVIET UNION, AND INDIA RELATING TO THE MID-1960s

Country	Crop land harvested (million hectares)	Agricultural output (million wheat units)	Value of machines (million dollars)	Number of tractors (thousands)	Petroleum fuel used in agriculture (million tons)
U. S.	117	365	27,100	4,800	about 30
U.S.S.R.	207	300	20,500	1,700	about 30
India	158	210	1,450	54	about 0·5

Note also that in recent years, outlays for external inputs in agriculture, in both the United States and the Soviet Union, have been on the magnitude of $16—$18 billion, or more than one-third of India's national product in recent years—more than two-thirds of its non-agricultural product ! Even with the most optimistic forecast of growth (5 per cent next year, accelerating to 10 per cent by 2000), the amount of domestic product 30 years hence would still be about $300—$350 billion. Agricultural expenses on a level with those of the U.S. and the U.S.S.R. would then be in the range of 4½—6 per cent of the domestic product. With performance anywhere below that maximum, even larger percentages would be required for high level mechanization at the time. Obviously, and by any variant of reckoning, India by 1985 will be a long way from where a highly capitalized agricultural economy may even be approached; by the year 2000 it could be approached only at the price of severe distortions.

With these general indications in mind, we may begin to examine the various cost items which would be involved in continued agricultural expansion to match the general growth situation.

Continued expansion of *fertilizer use* is undoubtedly to be expected. A recent report gives the following amounts for production capacity in existence or under way, as regrds nitrogen fertilizers,[19] as of January 31, 1968:

	(*thousand tons of N*)
Projects in production	849
Projects under construction	1,315
Projects approved but construction yet to start	629
Total of above	2,793

19. Government of India, Ministry of Petroleum and Chemicals, Report 1967-68, pp. 11 sq.

Besides the above, letters of intent had at the time been issued to private parties for the establishment of fertilizer factories for an additional capacity of 780 thousand tons of N, raising the total prospective capacity to 3,573 thousand tons of N.

These plans should, if implemented at all, be ready toward the end of the next five-year period.[20] For the next 15 years (up to 1983-84), Cummings and Herdt[21] have proposed, on the basis of carefully scrutinized technical assumptions, a range of possible rates of applications of fertilizers in India, from four to six times the amounts shown in Table VI for its last year, averaging five times those for 1967-68. This is under the assumption of a target of 5 per cent annual growth of agricultural output and a nearly equal rate of growth of agricultural value product, which will then assume the national product to grow by 6 per cent, or by 2.4 times in the same 15 years that agricultural output doubles. Increasing fertilizer use in the same period by five times will then raise the fertilizer cost to the magnitude of 2 per cent of the domestic product, unless fertilizer prices are drastically lowered.

The rate of "chemicalization" of Indian agriculture would be substantially raised but not excessively so. If "chemicalization" is expressed as kilograms of plant nutrient used per ton of wheat-equivalent (price weighted) output obtained, then this measure in Europe and North America as well as in Japan is presently in the range of 30-40, in India in 1967-68 8-9, or close to countries like Mexico. The increase quoted from Cummings and Herdt would bring it up somewhat above 20, or close to the present level of Taiwan. There would still be a good deal of room for expansion of fertilizer use up to the end of the century. How much would be needed at that time depends in part on population increase. Even as the rate of growth of agriculture gradually becomes a lesser fraction of the total growth rate, the long-term compound rate of growth of agriculture may remain a steady 5 per cent if, as reasoned above, total growth rate is accelerating. Agricultural output in the year 2000 may well have to be double that of 1985 (or close to five times that of 1970), and at the same time fertilizer use per unit of output may again double from 1985 to 2000, in which case total fertilizer use would be four-folded over the figure projected for 1985. Even under the optimistic assumption about acceleration of the NDP growth rate, this would still leave fertilizer expenses at or slightly above 2 per cent of domestic product, 30 years from now.

Expanding at a similar rate, the use of *agricultural chemicals* might continue to cost somewhat more than one-tenth as much as the fertilizers, thus in the range of 0.2—0.3 per cent of the national product, throughout the whole period under consideration.

20. Fourth Five-Year Plan 1969-74—Draft, *op. cit.*, p. 121, gives as consumption targets: N 3·7 million tons, P_2O_5 1·8 million tons, K_2O 1·1 million tons.

21. R. W. Cummings, Jr. and R. W. Herdt, The Future of India's Agriculture: Implications of the Green Revolution, unpublished MS, Chapter 9, Table 9:1.

The changes in costs of *pump-sets* and *electricity* for pumping will evidently depend upon the scope for continued expansion of irrigation. Present indications are that large-scale river control projects may not be expanded much in the foreseeable future, but there can be no doubt that small-scale irrigation works (local diversions, tube-wells) will have to expand greatly; controlled water supply is often vital to the successful utilization both of the new high-yielding varieties of field crops and of fertilizers.

The numbers quoted above (in Table VII) indicate a slightly rising share of agriculture in the consumption of electric power for production purposes. For 1973-74, the cost would be about 0.2 per cent of that year's domestic product.

The projections for depreciation and repair of pump-sets given above indicate something close to 1 per cent of the domestic product by 1975, not counting net investment in expansion of facilities.

The Fourth Plan (see footnote 12) gives figures for irrigation charges which appear to reflect also depreciation and interest costs and hence result in a somewhat higher level of external costs for agriculture than specified here.

To sum up the costs which are basic to Indian agriculture, the following shares in domestic product appear likely during the entire long-term period under discussion :

	(per cent)
Fertilizers	2·0
Other chemicals	0·2
Pump-sets (depreciation)	1·0
Electricity	0·2
Total of above	3·4

Considering also the need for continued rapid build-up of assets such as pump-sets (and other fixed installations for irrigation), it is clear that within the framework of normal-sized costs for agriculture, the scope for acquisition of other forms of capital will remain limited.

Tractors and Other Heavy Equipment; Motor Fuel

The tractor numbers in the 1960s were too small for any extrapolation of trend to be meaningful. The numbers were small enough also to represent only a minute fraction of the need for tractive power in India's agriculture. Domestic production of tractors is small, and is expected to have reached

13,000 in 1969 and to reach 20,000 by 1971.[22] The Draft Fourth Plan lists annual Indian tractor production as 6,300 in 1965-66, 14 thousand in 1968-69, and 50 thousand in 1973-74.[23] With such industrial beginnings, tractorization on India's 60 million farms is clearly no more than incipient in the 1970s.

The magnitude of costs involved in more comprehensive mechanization may be visualized by a comparison with the United States and the USSR. In both countries, the present level of mechanization involves an annual scrapping rate of about 200,000 units (middle-sized, wheeled farm tractors). Assuming these units to be in the price range of $3,500—$4,000 (the recent factory price level of such tractors in the United States), we obtain an annual depreciation charge of $750 million (Rs. 5,600 million), thus close to 2 per cent of India's national product in recent years and a correspondingly smaller fraction of subsequent, higher levels of domestic product. This is for replacements only and does not include repair and upkeep of units in continuous use.

Tractors do not do their work alone. Motor fuel consumption to a similar volume as in the United States and the U.S.S.R. (30 million tons annually in recent years), will cost something in the range of $1,500—$2,000 million per year, thus more than twice the cost of replacement tractors, or 4—5 per cent of India's national product in 1970.

Moreover, tractors are only one facet of a scheme for mechanized agriculture. The implements they draw are often different from and more expensive than those drawn by animals. In the United States in recent years, tractors have represented merely two-fifth of the cost of acquisition of equipment. Thus depreciation of tractors and other equipment would come to $1,500—$2,000, or about the same as motor fuel, and both categories together to some $3,000—$4,000 million—without yet counting repair and maintenance. In the United States, repairs and machinery on farms come to more than $2,000 million per year.

The costs of full mechanization would thus come to a magnitude of at least $5,000 million per year, not counting the added costs of a rapid build-up of the system through large annual net investments.

These $5,000 million (or Rs. 37,500 million) would represent over 10 per cent of India's domestic product in 1970, 4—5 per cent in 1985 and from $1\frac{1}{4}$ to 2 per cent in the year 2000, under the growth alternatives discussed above.

The summary conclusion is not hard to draw. With the indispensable expenditures for water supply and chemicals already occupying well over

22. "Tractor Takeover in South Asia," The Farm Index, Washington, D.C., United States Department of Agriculture, January, 1969, p. 15.
23. Fourth Five-Year Plan 1969-74—Draft, *op. cit.*, p. 261; and Notes on Perspective of Development in India: 1960-61 to 1975-76, Delhi, 1964, p. 58 sq.

3 per cent of India's domestic product throughout the long period, and with the obvious need for some more advanced equipment (other than pumps and tractive power), it is excluded that motorization could come very far the next decade and a half, and it will require very favourable growth assumptions for it to begin to be quantitatively significant—let alone "take over" from animal traction—before the turn of the century.

The above exercise in alternative growth assumptions throws a sharp light on the role of population growth. If it decelerates, *less* resources will be needed to expand agricultural production (because the demand for food expands less vigorously), but *more* external inputs could become available, because of the higher levels to which per capita income would rise. The dilemma posed by the Engel curve and the Simantov constants remains acute if the population growth rate continues high, but it is considerably relaxed if the population growth rate decelerates.

Second Thoughts : The Influence of Productivity Change

The above was written on the assumption of known productivity trends—not static productivity but known tendencies. It might be modified if productivities were substantially stepped up. Although this is hypothetical, and thus not a good basis for projections, some consequences may be discussed, albeit in entirely conjectural terms.

If productivity rises sharply in the industries producing inputs for agriculture, this could mean that the same output enhancing effect could be obtained at a cost which represents a smaller share of the national product. This is possible but not self-evident. Productivity increases do sometimes have different effects in capital-scarce and affluent economies. Let us distinguish two cases within either type of economy.

(*a*) Productivity rises because of increased substitution of capital for labour; this affects the social account supply cost of inputs on condition that the labour which is replaced finds alternative employment. Otherwise there might be no gain at all, or a smaller one, or even a net loss, in the social account rate of return to all resources available for production.

(*b*) Productivity rises because the same amount of capital (obtained at the same social account opportunity cost) will produce more than before. The substitution effect is then enhanced, and the chance becomes greater that its benefit will outweigh the hardship of unemployment. To a wide extent, such productivity increase may in fact be necessary to outweigh the burden of rapid population increase. In current-term national accounts, the effect may be concealed to the extent that the productivity gains stay where they occur, in which case the cost to agriculture of buying its external factors may remain more or less unchanged.

Take the instance of chemical fertilizers which, in the argument made above, will claim a substantial share of India's domestic product for quite some time to come. Increasing the productivity of fertilizer factories in India by replacing old lower productive establishments with new higher productive ones will make little difference to agriculture if the resources drawn upon represent (by their opportunity cost) the same fraction of the nation's resources as before. Even quite sharply rising productivity may not carry over into the factor prices paid by agriculture if the trend is the same throughout the urban sector and the gains stay there. Only if the industries supplying agriculture with external factors are raising their productivity substantially faster than other industry, will it be likely that some of the gain is carried over to agriculture in the form of input prices which represent a lowered share of the domestic product.

Someone may want to point to very spectacular gains in productivity—specifically in input-generating industries—which may be or become feasible within the time horizons discussed above. Such suggestions in the realm of "science fiction" can neither be refuted nor taken seriously in projective analysis.

The conclusions set forth above therefore stand, as far as knowledge available to us now is used as a basis. Under economically sound selection of priorities, motorization of Indian agriculture should not be a major factor until the 1980s, and in all likelihood should be at best partial toward the turn of the century. Prematurely accelerated motorization would be to the detriment of higher priority objectives in both agriculture and industry. There is a real risk that the highly unequal farm-size structure which resulted from the incompleteness of Indian land reforms may induce such premature motorization. Its private account gains to some people (the large farm owners and their employees) will be maintained only if no redistributive measures are taken to alleviate the plight of those left behind Sixty million farms are more than India can mechanize profitably within a generation, and 300 million farm people cannot be maintained in a capital intensive agriculture.