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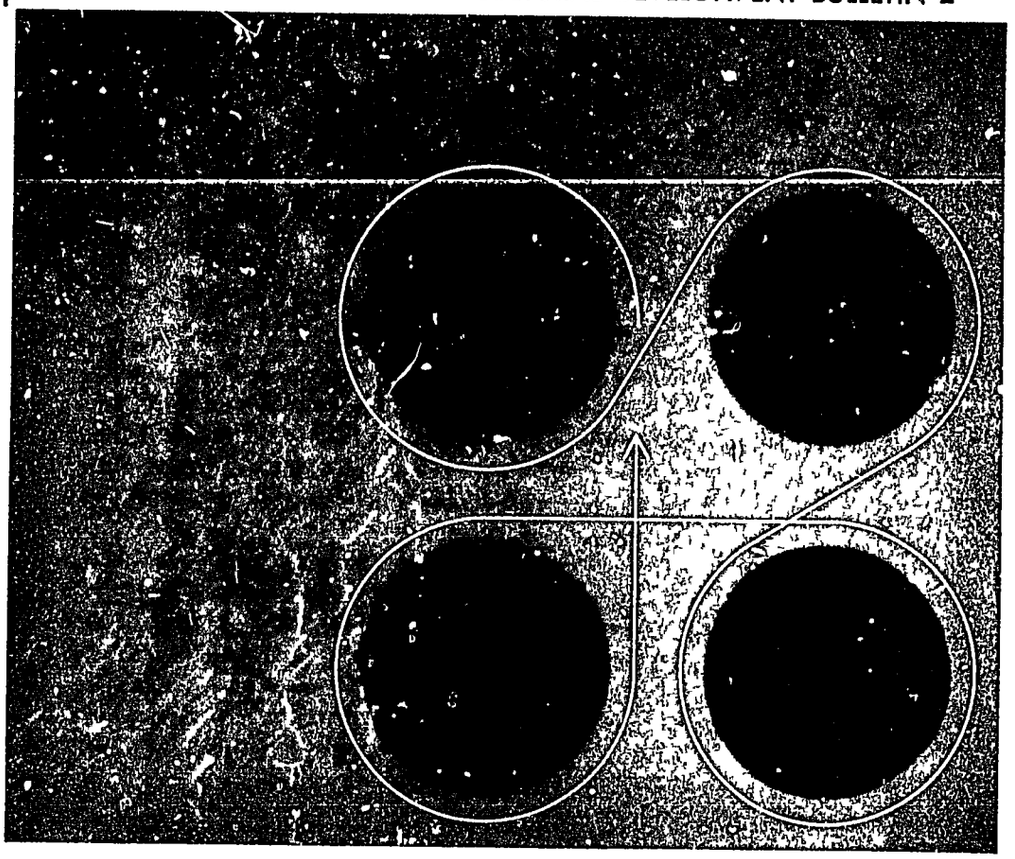

ESTIMATES OF CHANGE AND CAUSES OF CHANGE IN FOODGRAINS PRODUCTION INDIA, 1949-50 TO 1960-61

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ESTIMATES OF CHANGE AND CAUSES OF CHANGE IN FOODGRAINS PRODUCTION INDIA, 1949–50 TO 1960–61

UMA J LELE AND JOHN W. MELLOR

In agricultural development it is often difficult to identify the relevant production influences, let alone to quantify their influences sufficiently to allow precise estimation of future changes in production or future input needs Under such circumstances, a clear understanding of past changes assumes added significance

Estimates of the rate of change in foodgrains production in India from 1951 to 1961 provide a useful aid to estimation of future production increases They also facilitate estimation of the effects of past programs for encouraging increased production, and provide guidelines to future development policy

The 1951 to 1961 period is of special importance because it is the period of India's first two Five Year Plans Foodgrains account for roughly three-quarters of the gross area harvested in India and for two-thirds of the value of all agricultural production

Estimating rates of change in agricultural production in India for the First and Second Plan periods is particularly difficult because major changes occurred during this time in both the reporting area and in the methods of estimating yields In addition, erratic weather influences Indian agricultural production As a result, the trend may be seriously biased by the occurrence of a disproportionate number of good or bad years at one end of a series This effect may be particularly significant if an estimate is made for a period as short as 10 years

To enlarge the basis for a judgment concerning the trend in foodgrains production, this study presents estimates of the rate of change in foodgrains production which are derived from three separate approaches 1) measurement of trends in official estimates of foodgrains production, 2) estimation of

changes in domestic consumption of foodgrains, and 3) estimation of changes in major production inputs and of response coefficients in foodgrains production The third approach also provides an estimate of the relative importance of particular classes of inputs in achieving the estimated production increase

Each of the three approaches requires the use of data which are not fully reliable In addition, the data for the various approaches are at least in part interrelated Nevertheless, this study does provide a basis for an improved estimate of the trend in foodgrains production and it tests the mutual consistency of particular sets of plausible assumptions regarding consumption, production and production inputs

Considerable controversy exists concerning the absolute level of Indian foodgrains production [1] It must be emphasized, at the outset, that this study does not join that controversy It merely attempts to arrive at the rate of increase in production by using results obtained from different methods as cross-checks The aim of the paper is to point at the wide variability in absolute estimates underlying different rates of increase, and its implications in formulating future targets

[1] See for example the spirited debate concerning estimates of foodgrains production derived from the National Sample Survey and from the official figures of production of foodgrains, e g Government of India, Department of Economic Affairs, *National Sample Survey General Report One*, First Round, October, 1950–March, 1951, pp 77–78, Dandekar, V M, "On the National Sample Survey Estimates of Consumption of Foodgrains in India", *Indian Economic Journal*, Vol 1, No 2, pp 153–166, Sukhatme, P V, "National Sample Survey A Review," *Indian Economic Journal*, Vol 1, No 3, pp 239–252

TRENDS FROM OFFICIAL ESTIMATES OF FOODGRAINS PRODUCTION, 1949–50 to 1960–61

The ministry of Food and Agriculture, Government of India, publishes unadjusted estimates of foodgrains production [2] Because of changes in the geographic area covered and in the method of estimating yields, an adjusted set of estimates is also prepared and published [3] In addition, the Ministry publishes an index of foodgrains production that is based on the adjusted estimates The base for the index is 1949–50 because it is regarded as a more nearly normal year than 1950–51 or 1951–52, 1949–50 price weights are used in constructing the index Table 1 shows the three series for the years 1949–50 to 1960–61

Table 1 Official Estimates of Foodgrains Production, India, 1949–50 to 1960–61

Year	Production		Index of production[2]
	Unadjusted[1]	Adjusted[2]	
	(millions of long tons)		(1949–50 = 100)
1949–50	54	58	100
50–51	50	52	90
51–52	51	53	91
52–53	58	59	101
53–54	69	68	119
54–55	67	67	115
55–56	66	66	115
56–57	69	69	121
57–58	63	62	109
58–59*	75	75	130
59–60*	75	75	127
60–61†	79	79	135

Source 1 Government of India *Bulletin on Food Statistics* Ministry of Food and Agriculture, August 1961 and preceding years
2 Government of India *Agricultural Situation in India* Ministry of Food and Agriculture January 1962 and preceding years
* Partially revised
† Final estimates — subject to revision

The official estimates of foodgrains production may present a biased trend because of (1) error in the basic data and adjustments in the data, and (2) unadjusted estimates are notably lower than the adjusted estimates The next two sections will examine these issues

[2] Foodgrains are defined to include cereals (rice, jowar, bajra, maize, ragi, small millets, wheat and barley), and pulses (gram, tur or arhar, and other pulses)
[3] *Agricultural Situation in India,* Vol XV, No 5, Aug 1960, p 675

Adjusted Estimates of Foodgrains Production

Subsequent to 1951–52, the adjusted estimates of foodgains production differ very little from the unadjusted estimates In 1949–50 and 1950–51 the unadjusted estimates are notably lower than the adjusted estimates The adjustments cover several potentially conflicting influences

Traditionally, Indian foodgrains production estimates covered the British provinces and a few of the princely states With the merger of the princely states into the Republic of India, the area covered by foodgrains statistics was increased Most of the increase in area covered took place before the beginning of the First Plan Area covered increased by 91 0 million acres in 1949–50 and by 22 0 million acres in 1950–51 [4] Subsequent increases have been relatively less significant The requisite upward adjustment for the earlier years is difficult to make, however, because the area to which coverage was extended is generally regarded as providing lower yields per acre than the previously reported area How much lower these yields were in the earlier years is not precisely known

Before World War II, production estimates were the product of estimates of acreage harvested and yields per acre Yields were either directly estimated by local reporting authorities or were indirectly estimated by adjusting a "normal" yield by a condition factor The condition factor was a subjective adjustment that allowed for deviation of the actual yields from normal yields because of weather and other natural factors

Following World War II, a gradual transition was made to estimating yield by crop-cutting samples By 1958–59, nearly 90 percent of the official statistics were based on the crop-cutting method [5]

It is difficult to assess the effect on production estimates of shifting the traditional method of data collection to the crop-cutting method Based on the traditional method, yields were underestimated in some cases and overestimated in others [6] The adjusted figures represent an officially accepted concensus as to the balance of the relevant factors

The difficulty of assessing the validity of these adjustments provides one of the reasons why this study uses three largely independent methods for estimating trends in foodgrains production

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[4] V K.R V Rao, "Agricultural Production and Productivity During Plan Periods," *Indian Journal of Agricultural Economics,* Vol XVII, No 1, Jan–March 1962, page 10

[5] V G Panse and V S Menon "Index Numbers of Agricultural Production in India," *Agricultural Situation in India,* Vol XVI, No 5, Aug 1961, p 508, table 1

[6] S L Sharma "Progress in Agricultural Production Myth or Reality?" *Agricultural Situation in India,* Vol XVI, No 3, June 1961, p 258

Trends in the Official Estimates of Production

The unadjusted data in table 1 give a compound rate of increase of 3 9 percent per year The adjusted data increase at the rate of 3 4 percent per year as compared to 3 3 percent for the index of production The difference between the rates of increase obtained from adjusted estimates and the index of adjusted estimates results from the weights used in constructing the index

The rate of increase in foodgrains production estimated from the regression equations may be biased by the bunching of particular good or bad years at one end of the period The effect can be seen in table 2, which shows estimates of the rate of increase in production from the regression equations and from comparisons of selected individual years and sets of years

Table 2. Trends in Foodgrains Production Derived from Official Estimates of Production, India, 1949–50 to 1960–61

Technique	Years	Rate of increase (Percent per year)
Regression analysis		
Unadjusted estimates	1949–50 to 1960–61	3 9
Adjusted estimates	1949–50 to 1960–61	3 4
Index numbers	1949–50 to 1960–61	3 3
Comparison of averages and individual years, adjusted estimates		
Three year averages, centered on	1950–51 and 1957–58	3 4
Five-year averages, centered on	1951–52 and 1956–57	3 1
Individual years	1949–50 and 1958–59	2 9
Individual years	1950–51 and 1957–58	2 5

Source Computed from data in table 1

A rate of increase almost precisely the same as that from the regression fitted to the adjusted estimates comes from comparison of three-year averages centered on 1950–51 and 1957–58 There appears to be a clear upward bias in this estimate, however, because the average for the earlier period includes two crop years generally conceded to have been unfavorable, while the average centered on 1957–58 includes only one unfavorable year The same upward bias occurs in the comparison of the two five-year periods centered at 1951–52 and 1956–57 The rate of increase shown between these two points is 3 1 percent

It is possible that a less biased estimate is obtained by comparison of sets of years judged to be comparable Comparison of the two good years 1949–50

and 1958–59 provides an estimated rate of increase of 2 9 percent per year Comparison of the two poor crop years of 1950–51 and 1957–58 provides an estimated rate of increase of 2 5 percent per year This rate is less than three-quarters of the rate given by the regression equation fitted to the adjusted data

In the short period under consideration, the standard statistical techniques used cannot adequately separate production fluctuations because of weather from the underlying trend in production The evidence suggests that the rate of increase in production estimated by the regression equation fitted to the 1949–50 indices of production is biased upward by the occurrence of relatively more favorable years at the end of the period as compared to the beginning

ESTIMATE OF THE RATE OF CHANGE IN DEMAND AND CONSUMPTION OF FOODGRAINS

An alternative estimate of the rate of change in foodgrains production can be made by estimating the rate of change in consumption and adjusting for changes in imports and stocks In this study, the rate of increase in foodgrains consumption is derived from estimates of the rate of increase in foodgrains demand and foodgrains prices

The Rate of Increase in Demand for Foodgrains

The rate of increase in demand is expressed as a linear function of the rate of growth of population and the rate of growth of per capita real income

$$D = P_O + E_Y(Y_O)$$

where D=rate of increase in demand for foodgrains per year
P_O=rate of growth of population per year
E_Y=income elasticity of demand for foodgrains
Y_O=rate of increase in per capita real income per year

This study assumes constant income elasticities because the period under consideration is short, and the level of consumption was low at the beginning of the period In addition, it was preferred to err on the side of calculating an upper limit to the rate of increase in demand

Clearly, the usefulness of these calculations depends not only on the appropriateness of the function used, but also on the accuracy of the estimates of population growth, income growth and income elasticity of demand Considerable uncertainty exists in regard to each of the estimates used

The estimate of population growth is probably more reliable than the other two estimates However, there is certainly significant uncertainty regarding the accuracy of this figure as well This study uses a rate of population growth of 1 9 percent per year derived by the National Council of

Applied Economic Research from the 1951 and 1961 censuses of India[7]

The rate of growth of per capita national income in India is of course more difficult to estimate than the rate of growth of foodgrains production alone Foodgrains constitute nearly one-third of India's national income In addition, many of the other components of Indian national income are also the product of dispersed production systems whose output is exceedingly difficult to estimate

According to the *Third Five Year Plan,* per capita real income increased by 16 percent from 1951 to 1961[8] This figure, which represents a compound rate of increase of 1 5 percent per year will be used in estimating the change in demand for food in this period

If foodgrains production increased at a rate significantly different from official estimates, then it is likely that per capita real income also changed at a rate different from the official estimates This follows from the great importance of foodgrains in Indian national income Despite this, the official estimate is used as a first approximation, and to test the implications of choice of that figure

Choice of a figure for income elasticity of demand for foodgrains involves a number of complications because of the nature of the figure itself and because of the conflicting evidence that is available The succeeding discussion will deal with these problems at some length

Income Elasticity of Demand for Foodgrains

Foodgrains, as defined in Indian statistics, include grains for both human and animal consumption Therefore, an estimate of the total effect of income change on demand for foodgrains must consider both demand for direct human consumption and the demand for feedgrains derived from increased consumption of livestock products

Income Elasticity of Demand for Foodgrains for Human Consumption

The Food and Agriculture Organization of the United Nations, the National Council of Applied Economic Research, and G S Madala have published income elasticities of demand for foodgrains which are derived from the National Sample Survey These figures are generally similar, with an elasticity of about 0 3 to 0 4 for urban consumers and about 0 5 to 0 6 for rural consumers (table 3) Significantly lower elasticities were calculated by the National Council of Applied Economic Research from a consumer survey which they conducted in April, 1960

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[7] National Council of Applied Economic Research (NCAER), *Long Term Projections of Demand for and Supply of Selected Agricultural Commodities,* (New Delhi, April 1962), p 26

[8] *Third Five Year Plan,* Planning Commission, Government of India, 1961 p 35

Table 3 Comparison of Various Estimates of Income Elasticities of Demand for Foodgrains, India.

Sources	Urban	Rural
	(Cereals, value)	
FAO (NSS data)[1]		
1951–53	0 27	0 58
1954–55	0 25	N A.
1956–57	0 23	0 57
Madala (NSS data)[2]	0 3 to 0 4	0 5 to 0 7
	Foodgrains (Cereals and pulses, value)	
NCAER (NSS data)[3]	0 28	0 52
NCAER (NCAER Survey data)[3]	0 17	0 30

Sources 1 Food and Agricultural Organization *Agricultural Commodities Projection for 1970* (FAO Commodity Review) 1962 Special Supplement Rome May 1962
2 G S Madala Demand for Foodgrains During the Third Five Year Plan' *Indian Journal of Agricultural Economics* Vol XV No 2 April-June 1960 p 72
3 NCAER *Long Term Projections*

Since 1950, the National Sample Survey of the Government of India has conducted a series of inquiries into patterns of consumer expenditure By 1960–61, 16 rounds had been conducted The information collected by the Sample Survey has been used widely in studies of consumption and projections of future demand in India Since the National Sample Survey does not provide data on household incomes, income elasticities must be derived from expenditure elasticities

Unlike most rounds of the National Sample Survey, the NCAER Survey provided information on household income, quantities of purchases as well as values and on individual commodities rather than categories of commodities However, the NCAER study was based on a very small sample and covered only a single one-month period

For the following reasons, the present study uses the income elasticities derived from the National Sample Survey data

First, the present study estimates the rate of increase in demand during the past decade The NSS estimates are based on a series of surveys made throughout that period and give an average of the income elasticities for a number of years as well as for different seasons This average is perhaps more representative of the period studied than the NCAER figure, which is based on a single short period Concerned with future projections, the NCAER study correctly emphasizes data reflecting more recent economic influences

Second, the NCAER survey is based on a very small sample, indeed, the urban sample extended to only five towns

Finally, the elasticity coefficients based on the household consumption survey of the NCAER are not only low when compared with the NSS estimates, but they are not consistent with their own estimates of past change in consumption of foodgrains in India unless it is assumed that the elasticities are dropping sharply over time

A trend in the consumption of foodgrains has been estimated by the NCAER for the period 1949–50 to 1959–60 These data provide a compound rate of increase in consumption of 2 9 percent per year To be consistent with the other assumptions considered acceptable for this study, and with a rate of increase in consumption of 2 9 percent per year, the income elasticity of demand for foodgrains would have to be 67 or higher[9] This, of course, includes grain for livestock consumption as well as human consumption Even so, it is well above the NCAER's estimate from its own data and is even higher than the estimates from the NSS data

A weighted average of the rural and urban income elasticity coefficients calculated from NSS data by the NCAER gives an all-India income elasticity of demand for foodgrains for human consumption of 0 477[10] This figure will be used in this study

This elasticity appears to be lower than that for comparable income groups in Japan and for low-income workers in African cities[11]

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[9] If the rate of increase in consumption (C) is a linear function of the rate of population growth, rate of growth of per capita real income and the rate of change in prices, it can be expressed symbolically as follows

$$C = P_0 + E_y Y_0 + E_p P_1$$

Where P_0 = rate of growth of population
Y_0 = rate of growth of per capita real income
P_1 = rate of change in the deflated price index
E_y = income elasticity of demand for foodgrains
E_p = price elasticity of demand for foodgrains

If $C = 2\,9$, $P_0 = 1\,9$, $Y_0 = 1\,5$

then, $2\,9 = 1\,9 + E_y\,1\,5 + E_p P_1$

$1\,0 = E_p P_1 + E_y\,1\,5$

$E_y = 0\,67 - 0\,67 E_p P_1$

Since the rate of change in P_1 is positive (see p 15), and since Ep is negative, the above relationship suggests that Ey has to be equal to or greater than 0 67 depending on the magnitude of Ep and P_1

[10] The elasticities actually used by the NCAER in their projections were apparently arbitrarily determined and lie roughly half way between the estimates they made from the NSS survey data and those made from their own data NCAER, *Long Term Projections of Demand for and Supply of Selected Agricultural Commodities* (New Delhi, 1962), p 85 table 19

[11] *Demand Analysis of Food*, Ministry of Agriculture and Forestry, Government of Japan (March 1960) M Kaneda and B Johnston, "Urban Food Expenditure Patterns in Tropical Africa," *Food Research Institute Studies*, Stanford Univ, Vol II, No 3, Nov 1961, pp 229 275

If this elasticity is taken as essentially a quantity elasticity, it in effect implies a substantial positive income elasticity for calories [12]

The Demand for Feedgrains and a Weighted Income Elasticity of Demand for Foodgrains

The preceding income elasticity estimate refers to the effect of increased per capita income on the demand for foodgrains for direct human consumption Increased per capita incomes also induce increased consumption of livestock products, which, in turn, creates a demand for grain for livestock feed In India, milk is the livestock product most used for human consumption

To allow for the effect of increased use of foodgrains for livestock feed, the following assumptions were made

(1) That milk is representative, for these purposes, of all livestock products in India

(2) That the income elasticity of demand for milk is 1 5, as derived from Nation Sample Survey data, and that 1 5 also represents the derived income elasticity of demand for grain for livestock feed [13]

(3) That 2½ percent of foodgrain production is used to produce livestock products for human consumption [14]

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[12] There is, of course, considerable disagreement as to whether or not people in low income countries experience a continuing deficiency in calories For discussion of this point, see M K Bennett, *The World's Food,* (New York Harper & Bros, 1954) P V Sukhatme, "Food and Nutrition Situation in India," *Indian Journal of Agricultural Economics,* Vol XVII, No 2, April-June 1962, pp 1 28 V G Panse, "Food Availability and Requirements for India," *Agricultural Situation in India,* Vol XVI, No 6, Nov Dec 1961, pp 821 27

[13] For a fuller discussion of this, see de Ponteves, B C, *Alternative Projections of the Supply and Demand for Milk in India and Their Influence on Demand for Concentrate Feed, 1951–1976* Unpublished M S Thesis (Cornell University, 1963) There is some reason to think that a more than proportionate increase in feed use will occur as milk production increases If such is the case, then the demand estimates made on the assumption of the same elasticity for feedgrains as for milk will understate the elasticity for feedgrains

[14] This is the proportion of the value of all foodgrains which the National Income Committee estimate uses for livestock Their estimate includes work stock as well Cited by R S Srivastava, *Agricultural Marketing in India and Abroad* (Bombay, Vora & Co, 1960), p 40 Panse considers this a great underestimate (See V G Panse, *op cit*, p 824) For a full discussion of this matter, see Ponteves, *op cit*

With these assumptions, a weighted average income elasticity of demand for foodgrains was computed This figure of 0 50 is used as the income elasticity of demand for foodgrains for the purposes of estimating changes in demand from 1951 to 1961 Although presumably derived in a somewhat different manner, it is interesting to note that this is the same figure which FAO used as the quantity income elasticity for cereals for all India in their projection Their estimate is said to be discounted for the effect on the quantity demanded of both substitution of better quality and of urbanization [15]

The Rate of Increase in Demand for Foodgrains

Given the preceding assumptions, the rate of increase in demand for foodgrains is estimated as

$$D = P_0 + E_Y \quad Y_0$$

where D = rate of increase in demand

P_0 = rate of increase in population

Y_0 = rate of increase in per capita real income

E_Y = income elasticity of demand for foodgrains

therefore, $D = 1\,9 + 0\,50 \times 1\,5 = 2\,65$

The Rate of Increase in Consumption

Given the rate of increase in demand for foodgrains, the rate of increase in consumption can be estimated if the rate of change in foodgrains prices and the price elasticity of demand for foodgrains are known

Rate of Change in Foodgrain Prices

Indian agricultural prices in the period 1950–51 to 1960–61 were characterized by a major decline from 1952–53 to 1955–56 and then a long recovery to a level in 1958–59 somewhat higher than the level in 1952–53

Table 4 depicts the wholesale price indices for cereals, pulses, and all foodgrains and a deflated price index for all foodgrains The annual figures are an average of the monthly indices of wholesale prices of foodgrains Wholesale prices are used because a national retail price index was not available The index for all foodgrains is a weighted average of the series for pulses and cereals The weights used are those in the All-India Wholesale Price Index

A deflator for the all foodgrains price index was derived by dividing national income in current prices by national income in 1948–49 prices This

[15] See Food and Agricultural Organization, *Agricultural Commodities Projections for 1970* (FAO) Commodity Review 1962, Special Supplement, Rome, May 1962

deflator was then converted to a 1952–53 base, since the price index was on a 1952–53 base

A regression equation fitted to the deflated index for the years 1950–51 to 1959–60 shows a rate of increase of prices of foodgrains of 0 4 percent per year Inclusion of 1949–50 and 1960–61 would in net provide somewhat greater rate of increase in foodgrain prices Foodgrain prices in 1960–61 were little changed from 1959–60 while foodgrain prices in 1949–50 were significantly lower than in 1950–51 [16]

For this study 0 4 is assumed to represent the trend in foodgrains prices in the period under consideration The length of period considered relative to the size of annual fluctuations in foodgrains prices clearly indicates that there may be substantial error in this estimate Later calculations implicitly assume that prices of livestock products increased at the same rate There is no reliable evidence concerning the trend in livestock product prices

[16] An index for 1949–50 on the base 1952–53 was not available and hence could not be used However, the index number of wholesale prices on the base 1939 indicates that the cereals component of the index was 457 4 in 1949–50 It reached a level of 483 in 1950–51 The general index was 385 4 in 1949–50 and increased to 409 8 in 1950–51

Table 4 Wholesale Price Index Cereals, Pulses, and all Foodgrains, India, 1950–51 to 1960–61
(Base 1952–53 = 100)

Year	*Cereals*	*Pulses*	*All foodgrains*	*Deflated index for all foodgrains*[a]
1950–51[b]	95	92	94	91
51–52	—	—	—	95[c]
52–53	100	100	100	100
53–54	98	91	97	96
54–55	80	59	76	85
55–56	76	62	73	80
56–57	96	81	93	94
57–58	101	82	97	97
58–59	107	104	106	102
59–60	104	94	102	97
60–61	104	93	102	—

Source Report on Currency and Finance, Reserve Bank of India various years
a Derived. See text for method of derivation.
b Estimated
c Indices for 1951–52 were not available Therefore, the deflated index for all foodgrains for the year was interpolated

Price Elasticity of Demand

No estimates of the price elasticity of demand for foodgrains as a whole are available for India Estimates by the National Council of Applied Economic Research for rice and wheat alone could not be used as an estimate of price elasticity of demand for foodgrains as a whole [17]

Fortunately, theory relating to consumer demand provides helpful limits to estimates of the elasticity coefficient The Slutsky-Schultz relation is of particular help in this regard A mathematical proof is provided by Wold for the theorem, which states that "the income elasticity equals the sum of price and cross elasticities for the individual demand of any commodity"[18] This holds only in the case of an individual consumer It does not apply to an aggregative market analysis where different rates of increase in incomes are experienced Frisch infers relations for the total market from relations applicable to a "representative consumer," thus avoiding the problem of aggregation

Although the sum of cross elasticities of demand for foodgrains in a low income country may be quite low it seems very unlikely that it would be negative Hence, the price elasticity of demand is likely to be about the same or somewhat larger than the income elasticity For the purposes of later calculations it will be assumed that the price elasticity is – 0 50, which is the same as the income elasticity assumed but with the sign reversed This assumption implies that there are not close substitutes for foodgrains within the context of the Indian economy If there are close substitutes, the price elasticity can be expected to be larger than the income elasticity, with sign reversed [19]

Rate of Increase in Consumption

With these assumptions, we can calculate the rate of increase in consumption, as follows

$$C = P_0 + E_Y \cdot Y + E_P \quad P_1$$

where P_0 = rate of growth of population

Y = rate of growth of per capita real income

E_Y = income elasticity of demand

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[17] NCAER, *op cit*, p 80, Table 15 Price elasticity of demand for rice and wheat are estimated to be — 19 and — 73, respectively

[18] Wold and Jureen, *Demand Analysis* (New York Wiley & Sons, 1953), p 111 Frisch has summarized the above theorem in his article, "A Complete Scheme for Computing all Direct and Cross elasticities in a Model with many Sectors," *Econometrica*, Vol XXVII, No 2, May August 1959, pp 177–196

[19] For further discussion of this point see *Agricultural Commodities Projections for 1970*, FAO Commodity Review 1962, Special Supplement, Rome, p A–21

P_1 = rate of change in prices

E_P = price of elasticity of demand

P_0 has been estimated as 1 9 percent per year, Y as 1 5 percent per year, E_Y as 0 50, P_1 as 0 4 percent per year, and E_P as – 0 50

Therefore, C = 1 9 + 1 5 (50) + (0 4) (–0 50) = 2 45

Consumption of foodgrains in India in the period 1951–61 is therefore estimated to have increased at the rate of 2 45 percent per year

The Rate of Increase in Domestic Foodgrains Production

Given the rate of increase in consumption of foodgrains, the rate of increase in domestic production can be estimated by adjusting for imports and change in stocks

Imports of Foodgrains

Table 5 shows imports of foodgrains into India for the period 1949–50 through 1960–61 A regression equation fitted to the import data shows an insignificant rate of change in imports of – 01 percent per year As the table makes clear, imports have reduced fluctuations in the supply of foodgrains, but do not show an upward trend in this period It can also be seen that imports are a small percentage of total foodgrains

Table 5 Imports and Production of Foodgrains, India, 1949–50 to 1960–61

Year	*Imports*[1]	*Production*[2]	*Imports plus production*	*Imports as percent of imports plus production*
		(millions of long tons)		
1949–50	3 7	57 6	61 3	6
50–51	2 2	52 2	54 5	4
51–52	4 8	52 7	57 5	8
52–53	3.9	58 6	62 5	6
53–54	2 0	68 6	70 7	3
54–55	0 8	67 2	68 0	1
55–56	0 7	65 8	66 5	1
56–57	1 4	68 8	70 2	2
57–58	3 6	62 4	66 0	5
58–59	3 1	74 5	78 6	4
59–60	3 8	74 7	78 5	5
60–61	N A	79 3	—	—

Source 1 NCAER, *Long-Term Projections of Demand for and Supply of Selected Agricultural Commodities*, (New Delhi 1962)
2 *Agricultural Situation in India*, Ministry of Food and Agriculture (adjusted estimates)

Changes in Stocks of Foodgrains

Few statistics are available on stocks of foodgrains Although stocks of foodgrains presumably vary from one year to another, there is no evidence of a trend in stocks during the period under consideration

Rate of Increase in Domestic Foodgrain Production

With no trend in either imports or stocks, it can be assumed that domestic production has increased at the same rate as domestic consumption Thus, we have an estimate that domestic production has increased at the rate of 2 45 percent per year during the period from 1951 to 1961 This is the same estimate derived from taking the trend as shown by the official production estimates for the two poor years of 1950–51 and 1957–58

In making this estimate of the rate of change in consumption a number of major judgments were involved The two most likely sources of error tend to give an inflated rate of change

First, the rate of increase in per capita income may have been overestimated This is particularly likely because foodgrains contribute about a third of the national income Presumably, the national income figure used assumes a rate of increase in foodgrains production of the order of 3 3 percent per year A lower estimate for foodgrains would, therefore, lower the national income estimate On the other hand, the difficulties of complete accounting for growth in parts of the non-agricultural sector, such as small industry, should not be ignored as possible causes for understating growth in national income

Second, it is likely that estimating the price elasticity of demand at 0 5 places it too low This figure assumes that the sum of the cross-elasticities is zero, which is an unlikely assumption even in a low-income society

In the judgment of the authors, the likelihood of counterbalancing factors causing an underestimation of growth in consumption appears slight Thus, the estimate of a 2 45 percent rate of growth of consumption is more likely an overestimate than an underestimate

THE AGGREGATE EFFECT OF INCREASED INPUTS ON FOODGRAINS PRODUCTION

A third estimate of the increase in foodgrains production can be made by estimating the increase in key production inputs or sets of inputs and attaching to them a set of independently derived response coefficients

Four sets of inputs are both measurable and important They are irrigated land, unirrigated land, labor, and inorganic fertilizer All other inputs are assumed to change proportionately with these four inputs and their effect to be reflected with respective response coefficients

The response coefficients were estimated from various contemporary sources including data from farm surveys and experiment stations It would have been useful to have also derived the response coefficients from multiple regression analysis of time series data regarding input quantities and output However, the nature of the input data did not lend itself to this approach

Inputs of actual or potential importance which are not separately measured are animal power, tools and implements, improved seeds, manures and other organic fertilizers, and improvement in the qualitative aspect of labor such as might arise from the community development and extension program

Animal power plays an important part in Indian agriculture However, the meagerness of the data on the cattle population and on the actual work done by animals did not permit its inclusion as a separate input category It is probably reasonable to assume that the use of animal power has increased in proportion to the land input

Farm tools and implements are also considered to increase apace with increase in land area More error would be involved in this assumption if major improvements had occurred in tools and implements In this connection, the Ford Foundation Team observed that though impressive examples of the effectiveness of improved tools and mechanization are observed throughout India, "for the masses of cultivators, very little change has occurred "[20]

Improved seeds offer substantial scope for increasing agricultural production It is, however, difficult to appraise the accuracy of available statistics on the spread and effectiveness of improved seeds during the first two Plan periods In addition, there are logical reasons to expect the use of improved seeds to be closely associated with the use of inorganic fertilizers For this reason, the impact of improved seeds is assumed to be proportionate to the increase in inorganic fertilizers The available data on improved seeds will be examined in the section dealing with inorganic fertilizers

Manures and other organic fertilizers are also often depicted as a potentially major source of production increase What meager data are available suggest that their present contribution is insignificant One estimate places the total nitrogen from all types of manure used in 1960–61 as 16,000 tons [21] Again, it is assumed that the effect of such inputs is included in the land input.

Improvement in the quality of labor of course can not be measured by usual techniques For this study, such improvement must be considered either proportionate to the use of inorganic fertilizer, which is probably a

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[20] Ford Foundation Team, *Report on India's Food Crisis and Steps to Meet It*, Government of India, 1959, p 235

[21] NCAER, *op cit*, p 123

technically logical assumption, or proportionate to the land input, and its coefficient included with one or the other of these An alternative assumption is that programs of qualitative improvement in the work force have not as yet had significant effect

It is clear that a truly heroic set of assumptions are made in these estimates of the effect on production of increased input The value of these estimates may lie more in indicating the implications of particular sets of assumptions about these matters than in providing an estimate of actual production increase

Increased Land Input

Estimating the Acreage of Land Input

The Ministry of Food and Agriculture provides statistics regarding the total land area under foodgrains and the irrigated area under foodgrains Since data for the irrigated area under foodgrains were available only up to 1956–57, data for the later years were projected from the trend for the period 1949–50 to 1956–57 The unirrigated area under foodgrains is derived as the difference between the total area and the irrigated area These data are shown in table 6

Table 6 Gross Area Under Foodgrains, India, 1949–50 to 1960–61

Year	*Unirrigated area*[a]	*Irrigated area*	*Total area*
		(millions of acres)	
1949–50	201	44	245
50–51	195	45	240
51–52	194	46	240
52–53	205	47	252
53–54	220	49	269
54–55	215	52	267
55–56	223	50	273
56–57	225	50	275
57–58	216	51[b]	267
58–59	227	53[b]	280[c]
59–60	228	54[b]	282[c]
60–61	224	55[b]	279[d]

Source Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India

a Derived from estimates of total area and irrigated area
b Extrapolated
c Partially revised subject to revision
d Final estimates subject to revision

Estimating the Response Coefficient for Land Input

In estimating the effect on production of increased land under foodgrains, the assumption is made that the added irrigated and unirrigated land will have the same average yield as the irrigated and unirrigated land under foodgrains in the period 1949–50 A number of complex factors are of course at work On the one hand, it might be assumed that the added land would be less productive than the average of that previously cultivated On the other hand, the added land might represent land made available through new irrigation and reclamation technology, which is of higher average productivity With no basis for choosing in this matter, a constant rate of productivity was assumed

For estimating response coefficients, 1949–50 is taken as the base year because it was a relatively normal year in regard to weather, and because it is a representative year in regard to geographical coverage of crop estimates Seventy-two percent of the post independence increase in the reporting area had taken place by that time

The response coefficient for increased land input is estimated by dividing total production of foodgrains in the base year by the acreage in that year Because available statistics do not divide production according to irrigated and unirrigated land, an estimate of the difference in yields on irrigated and unirrigated land was made After examining a number of figures, a 30 percent higher foodgrain yield on irrigated land was settled upon

The NCAER, after careful examination of a number of sources, estimated that, on the average, irrigation caused a 30 percent increase in yield per acre for rice, and 20 percent for wheat -[2] In contrast, the Ford Team estimated an increase of 0 20 to 0 25 tons of grain per acre on irrigated land, as compared to unirrigated land -[3]

The Ford figure represents a yield on irrigated land nearly twice the overall average yield of foodgrains in India This estimate probably represents the effect not only of irrigation but of a large number of ancillary technological changes as well It is unlikely that these changes were important in the 1951–61 period

Unpublished survey data from a number of areas suggest yields on irrigated acreage ranging from 15 to 60 percent higher than on unirrigated land In the face of this evidence, the figure of 30 percent was arbitrarily settled upon as representing the increment in yields to be expected from irrigated as

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[22] NCAER, *op cit*, p 242, Table A-71

[23] The Ford Team, *op cit*, p 47

compared to unirrigated land Thus, response coefficients per acre of irrigated and unirrigated land were derived as follows

Total Production in 1949–50

$$= (\text{Unirrigated Land} \times \text{Response Coefficient}) + (\text{Irrigated Land} \times \text{Response Coefficient})$$

$$\text{i e, } 57\,60 = (201\,062x) + (44\,268 \times 1\,3x)$$

$$= 258\,6104x$$

$$x = 0\,2227$$

$$1\,3x = 0\,2895$$

Using the acreage figures shown in table 6, and a response coefficient of 0 2227 tons per acre for each acre of unirrigated land and 0 2895 tons per acre of irrigated land, total production from land was calculated and is presented in table 7 These figures represent the response due to land and the complement of labor and other resources existing in the 1949–50 period The effect of a disproportionate increase in labor, inorganic fertilizers, and associated inputs is considered in succeeding sections

Table 7. Foodgrains Production Attributed to Land Input and Associated Factors, India, 1949–50 to 1960–61

Year	Total Production		Cumulative increase over 1949–50	
	Irrigated Land	Unirrigated Land	Irrigated Land	Unirrigated Land
	(millions of long tons)			
1949–50	12 8	44 8	0 0	0 0
50–51	13 1	43 5	0 3	−1 3
51–52	13 3	43 1	0 5	−1 6
52–53	13 6	45 7	0 8	1 0
53–54	14 2	49 1	1 4	4 3
54–55	15 0	47 8	2 2	3 0
55–56	14 7	49 6	1 8	4 8
56–57	14 6	50 1	1 8	5 3
57–58	15 0	48 0	2 2	3 3
58–59	15 3	50 5	2 5	5 8
59–60	15 7	50 7	2 8	6 0
60–61	16 0	49 9	3 2	5 5

Increased Labor Input

The previous estimate of increased output ascribed to increased land input included the effect of a proportionate increase in labor and other inputs An estimate will now be developed for the effect of an increase in labor input per acre of irrigated and unirrigated land, first estimating the quantity of labor used, and then estimating a response coefficient to apply to that labor input

An Estimate of Increased Labor Use Per Acre

The estimate of the increase in labor use per acre requires four steps estimation of the total agricultural labor force, estimation of the proportion of the agricultural labor force actually used in productive processes, division of the labor actually used into that part used on foodgrains and that part used on other agricultural production, and finally a division of the labor used on foodgrains into a) an increase proportionate to the increase in irrigated and unirrigated land, and b) additional labor per acre

The Total Agricultural Labor Force

Estimates of the agricultural labor force used in this study are derived directly from figures for total population, the proportion of the population which is rural, and the proportion of the total rural population which constitutes the agricultural labor force The total population figures were taken from the population censuses of 1951 and 1961 [24]

According to the censuses, the proportion of population in agriculture remained at 70 percent during the last decade The working force in agriculture was estimated to be 40 percent of the total rural population by the 1951 census of India It is assumed that this proportion did not change from 1951 to 1961 On this basis, the labor force in agriculture was calculated as 98 million in 1951 and 123 million in 1961 From these estimates, the labor force in agriculture was estimated for each year from 1949–50 to 1960–61 assuming a constant rate of growth for the whole period (table 8)

Agricultural Labor Actually Used

Because of the response coefficient to be used, it is necessary to exclude from total agricultural labor that part not actually used in production The various farm management studies conducted by the Ministry of Food and

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[24] *Census of India,* 1951, Vol I, Part I B, Appendices (Delhi, 1955), pp 234–235, as quoted in *Studies in Indian Agricultural Economics,* The Indian Society of Agricultural Economics (Bombay, 1958), p 226, and G Parthasarthy, "Manpower Utilization within Agriculture," *A I C C Economic Review,* Vol XIII, Nos 14–16, January 4, 1962, p 31

Agriculture provide data from which such a computation can be made[25] Using the data from those studies, D Etherington has made labor use estimates for five different states of India for 1954–55[26] These labor use estimates varied from 0 8 to 2 3 months of labor per acre, one month being equal to 30 eight hour days A weighted average of these estimates was taken using gross land under cultivation in 1954–55 in these five states as the weights The weighted average obtained was 1 53 months per acre This coefficient was multiplied by the gross land under cultivation to estimate the total labor use in agriculture Division of this coefficient by the total persons in the agricultural labor force provides an average of slightly over five months of labor per person

Statistics on the aggregate use of agricultural labor were not available from any other source and could not be used as a cross-check *Agricultural Wages in India,* published by the Ministry of Food and Agriculture, gives normal daily working hours along with the wage rates Daily working hours average eight, however, they vary not only from place to place and month to month, but also from crop to crop Also, the data do not give the actual amount of labor used per day, and hence cannot be used to check the validity of the above estimates of labor use per person Likewise, these data do not give the average days worked per month or months worked per year

No information was available on changes in the patterns of work schedule of the rural population for the period under consideration It was, therefore, assumed that labor use per person for the period under consideration remained the same as in 1954–55, and that the increase in the total labor input was directly related to increases in population

The average labor use per person, and the labor force in agriculture during the period 1949–50 to 1960–61 were used to derive the total labor use in agriculture

The Agricultural Labor Force Used on Foodgrains

In allocating a portion of total labor use to production of foodgrains, it was assumed that the ratio of labor use in foodgrains to total labor use

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[25] *Studies in the Economics of Farm Management in Punjab,* Department of Agriculture, Government of India (Albion Press, 1958)
Studies in the Economics of Farm Management in Bombay, Department of Agriculture, Government of India (Albion Press, 1958)
Studies in the Economics of Farm Management in Madras, Department of Agriculture, Government of India (Albion Press, 1958)
Studies in the Economics of Farm Management in Uttar Pradesh, Department of Agriculture, Government of India (Albion Press, 1958)
Studies in the Economics of Farm Management in West Bengal, Department of Agriculture, Government of India (Albion Press, 1958)

[26] D Etherington, *op cit*

is the same as the ratio of land under foodgrains to total land under cultivation.

Table 8 shows the various estimates regarding labor input

Table 8. Estimated Labor Use in the Production of Foodgrains, India, 1949–50 to 1960–61

Year	*Total agricultural labor force*	*Labor use in agriculture*	*Labor use in foodgrains*
	(millions of persons)	*(millions of man-months)*	
1949–50	96	479	366
50–51	98	490	362
51–52	100	501	365
52–53	103	513	380
53–54	105	524	402
54–55	107	536	402
55–56	110	548	413
56–57	112	561	418
57–58	115	574	429
58–59	117	587	441
59–60	120	600	448
60–61	123	614	458

Increased Labor Use Per Acre

The increase in labor use per acre is computed as a residual, after labor required for an increase proportionate to acreage is subtracted from total available labor For this purpose, labor used per acre in the base year 1949–50 is taken as the standard For each successive year, the increase in acreage is multiplied by a standard labor requirement per acre to estimate the total labor required for a proportionate increase in land Since irrigated land requires a greater labor input than unirrigated land, a division of the labor input according to irrigated and unirrigated land has been made.

The amount of additional labor used on irrigated land varies according to the type of crops as well as according to the type of irrigation. The Farm Management Study for the Punjab observes that the "use of human labor on unirrigated crops per acre is roughly half of that on irrigated crops"[27] In Bombay state, labor per acre on irrigated land is reported to be 50 percent higher than that on unirrigated land[28]

[27] *Studies in the Economics of Farm Management in Punjab,* Department of Agriculture, Government of India (Delhi Albion Press, 1958), p 77

[28] *Studies in the Economics of Farm Management in Bombay,* Department of Agriculture, Government of India (Delhi Albion Press, 1958), p 22

Only the Farm Management Studies for Madras estimated the additional labor applied to irrigated land according to different crops [29] Data were presented only for rice, bajra, jowar, and ragi These four crops constituted 63 percent of the total foodgrains production in India in 1949–50

For lack of additional information, an estimate of the additional labor required per irrigated acre was taken as an average of these data from Madras state, weighted by the percent contributed by these four crops to the total production of foodgrains in India in 1949–50

Table 9 shows the amount of additional labor input on irrigated land in the Madras study area and the production of the above four crops as percentages of the total production of foodgrains in 1949–50 The weighted average computed from these data states labor input per acre on irrigated land to be approximately 40 percent higher than that on unirrigated land

Table 9 Increase in Labor on Irrigated Land as Percent of Labor on Unirrigated Land for Various Crops, India

Crop	Additional labor on irrigated land[a]	Weights[b]
	(Percent)	
Rice	45	43
Jowar	25	11
Bajra	25	6
Ragi	31	3
Weighted average	39	

a For Madras as shown in *Studies in the Economics of Farm Management in Madras*, Ministry of Food and Agriculture 1958
b Weights represent total production of the crop as a percent of total foodgrains production for 1949–50 for all of India

Classification of total land under foodgrains into irrigated and unirrigated land was available for the year 1949–50

Labor per acre on unirrigated and irrigated land was determined as follows

$$\text{Total Labor Flow} = (\text{Unirrigated Land} \times \text{Labor per Acre}) + (\text{Irrigated Land} \times 1\,4 \text{ Labor per Acre})$$

$$\text{i e, } 365\,8107 = (202\,309z) + (43\,021 \times 1\,4z)$$

$$z = 1\,39 \text{ months}$$

$$1\,4z = 1\,95 \text{ months}$$

[29] *Studies in the Economics of Farm Management in Madras*, Ministry of Food and Agriculture, Government of India, (Delhi Albion Press, 1958), p 127 Table 10A

Using these coefficients and the year-to-year changes in acreages, the total estimated labor force is allocated among labor on unirrigated land, labor on irrigated land, and a residual stated as increased labor per acre Table 10 shows these data on an aggregate basis Table 11 shows increments in labor used over the base year

It is interesting to note that with the assumptions made, in the period 1949–50 to 1960–61, 60 percent of the increase in estimated labor use was absorbed through increased acreage, leaving 40 percent of the increment either unemployed or contributing to intensification of production through more labor input per acre of land Up to 1957–58 increased acreage absorbed essentially all of the increased labor input It should be remembered that it is assumed in estimating labor availability that the proportion of man-time available for work did not change during the period

Estimating the Response Coefficient for Labor Input

The estimate of production in this section takes 1949–50 as a base, with its given set of inputs Thus, separation of the labor and land input for that year is not of concern Likewise, the assumptions concerning the effect on production of more land implicitly include the contribution of a proportionate increase in labor

A response coefficient is needed for that part of labor input which represents an increase in labor use per acre of land

For the purposes of this exercise, it is assumed that the productivity of the labor increment during the 1951–61 period is represented by the average wages of field laborers in the year 1951–52 It is implicit in this assumption that the marginal productivity of agricultural labor was constant for the segment represented by the increased input over this period The implications of this assumption will be seen in later presentations

It is commonly argued that the marginal productivity of agricultural labor in India is zero [30] Attaching a zero marginal product coefficient to labor representing intensification of production has the same effect as assuming no increase in the intensity of labor input Hence, the implications of such an assumption can be readily seen in summary tables 16 and 17 by deleting the response from this input

In estimating the wage rate, data for the base year 1949–50 were not available Therefore, a weighted average of the wages of field laborers was taken for the year 1951–52 using agricultural population in the reporting

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[30] For a fuller discussion of this matter, see John W Mellor, "The Use and Productivity of Farm Family Labor in Early Stages of Agricultural Development," *Journal of Farm Economics*, August, 1963

Table 10. Total Labor Use in Foodgrains Production, India, 1949–50 to 1960–61

Year	Labor on unirrigated land	Labor on irrigated land	Increased labor per acre	Total labor
	(millions of man-months)			
1949–50	280	86	0	366
50–51	272	88	1	362
51–52	270	89	5	365
52–53	286	89	5	380
53–54	307	96	−1	402
54–55	299	101	1	402
55–56	310	99	4	413
56–57	313	99	6	418
57–58	301	101	28	429
58–59	316	103	22	441
59–60	317	106	26	448
60–61	312	108	37	458

Table 11 Cumulative Increase in Labor Use over 1949–50 in Foodgrains Production, India, 1949–50 to 1960–61

Year	Labor on unirrigated land	Labor on irrigated land	Increased labor per acre	Total labor
	(millions of man-months)			
1949–50	0	0	0	0
50–51	−8	2	1	−4
51–52	−10	3	5	−1
52–53	6	3	5	15
53–54	27	9	−1	36
54–55	19	15	1	36
55–56	30	12	4	47
56–57	33	12	7	52
57–58	20	14	28	63
58–59	36	17	22	75
59–60	37	19	26	83
60–61	32	22	37	93

states as weights The calculated average wage was 1 50 rupees per day [31] Since in earlier calculations labor flow per month was taken as 30 days, this works out to 45 rupees per month Assuming an average of slightly over five such months of employment, this represents an annual product of about 245 rupees per person

To convert the wage rate to a foodgrain equivalent, a weighted average of 1949–50 harvest prices of all foodgrains was taken The percent contributions of the respective foodgrains to total foodgrains production in 1949–50 were used as weights The weighted average of prices so obtained was 440 rupees per long ton Thus, the physical product of labor for this period is taken as 0 1 tons per month

Application of this response coefficient to the previously derived estimates of labor use accompanying increases in unirrigated and irrigated land and increased labor use per acre gives the results shown in tables 12 and 13 Since the same response coefficient was used for each category of labor input, the relative weight of each class is the same as for the input quantities shown in tables 10 and 11

[31] Quotations on wage rates for different districts were taken from the *Abstract of Agricultural Statistics*, 1951–52, Ministry of Food and Agriculture, Government of India. A simple average of wages at district level was taken to arrive at the state figure which was then weighted by the agricultural population in the state to obtain the weighted average

Table 12 The Calculated Effect of Labor Input on Foodgrain Production, India, 1949–50 to 1960–61

Year	Labor on unirrigated land	Labor on irrigated land	Increased labor per acre
	(millions of long tons)		
1949–50	28 6	8 8	0
50–51	27 8	9 0	0 1
51–52	27 6	9 1	0 5
52–53	29 2	9 1	0 5
53–54	31 4	9 8	−0 1
54–55	30 6	10 4	0 1
55–56	31 7	10 1	0 4
56–57	32 0	10 1	0 6
57–58	30 7	10 3	2 8
58–59	32 3	10 6	2 2
59–60	32 4	10 8	2 6
60–61	31 9	11 0	3 8

Table 13. The Calculated Cumulative Effect of the Increment to Labor Input Since 1949–50, India, 1949–50 to 1960–61

Year	Labor on unirrigated land	Labor on irrigated land	Increased labor per acre
	(millions of long tons)		
1949–50	0 0	0 0	0 0
50–51	–0 8	0 2	0 1
51–52	–1 0	0 3	0 5
52–53	0 6	0 3	0 5
53–54	2 8	1 0	–0 1
54–55	2 0	1 6	0 1
55–56	3 1	1 3	0 4
56–57	3 4	1 3	0 6
57–58	2 1	1 5	2 8
58–59	3 7	1 8	2 2
59–60	3 8	2 0	2 6
60–61	3 3	2 2	3 8

Increased Inorganic Fertilizer Input

Estimating Inorganic Fertilizer Input

The Food and Agriculture Organization of the United Nations reports the total amount of various types of inorganic fertilizers available in India for the period 1950–51 to 1958–59 Although there is some evidence that stocks increased somewhat during the period studied, these data will be taken as representing actual consumption in the respective years

The Government of India has estimated that in the Third Five Year Plan, 61 percent of all inorganic fertilizer will go to foodgrains production It will be assumed that this also applies to the period from 1951 to 1961 The resulting data regarding inorganic fertilizer availability are shown in table 14

Nitrogen dominates the total tonnage of inorganic fertilizers There is also considerable difficulty in estimating response coefficients for non-nitrogenous fertilizers As a result, the tonnage of all inorganic fertilizer is totaled and a single response coefficient is attached to that tonnage

Estimating the Response Coefficient for Inorganic Fertilizer

Many fertilizer trials under various conditions have been run in India Using data from a variety of sources, the NCAER has constructed a set of weighted average response coefficients The NCAER then discounted these coefficients by 15 percent to correspond to usage by farmers They estimated the response to improved seed separately, hence, the NCAER fertilizer coefficients do not reflect the added effect of improved seed

Table 14. Total Availability of Inorganic Fertilizers, India, 1950-51 to 1958-59

Year	Nitrogen	Phosphate	Potash	Assumed allocation to foodgrains[a]
	(thousands of metric tons of nutrients)			
1950-51	47	13	—	36
51-52	51	10	7	42
52-53	105	20	3	78
53-54	85	14	5	64
54-55	117	14	16	90
55-56	142	12	7	98
56-57	165	18	8	116
57-58	179	26	20	137
58-59	180	35	19	143

a See text for method of derivation
Source Food and Agriculture Organization *An Annual Review of World Production and Consumption of Fertilizers* 1951-52 to 1960-61 (Rome)

The undiscounted NCAER estimates are very similar to those estimated by Panse, Yates and Finney [32] Their data suggest a response coefficient for all foodgrains of about 10 pounds of grain per pound of fertilizer One set of estimates of the impact of inorganic fertilizers on foodgrains production has been made using this response coefficient. Because this is a conservative estimate by the standards of a number of trials and because no allowance is made for the effect of improved seeds, an alternative response coefficient of 16 pounds of grain per pound of fertilizer is also used These estimates are shown in table 15 It will be noted that the total effect on production of inorganic fertilizers has been very small during this period Further, in the end year, 1960-61, the effect on production of the 60 percent difference in response coefficients used is only one million tons In the summary tables, estimating total production increase, the 16-pound response coefficient will be used This response coefficient certainly represents an upper limit for response, even assuming it is to cover a complementary input of improved seed, insecticide, management skills, and other types of technology

The Effect of Improved Seeds

It has been assumed for this study that the impact of improved seeds is largely associated with the higher fertility levels accompanying use of inorganic fertilizers Hence, the response of these two inputs has been combined in the single coefficient for inorganic fertilizers Available data re-

[32] As cited by V S Menon, "Role of Fertilizers in India," *Agricultural Situation in India*, Vol XVII, No 1, April 1962, pp 27-36

Table 15. Increase in Production Due to Increased Input of Inorganic Fertilizers, India, 1950–51 to 1960–61

Year	*Quantity of fertilizer input*	*Total returns with response of 10 pounds*	*Total returns with response of 16 pounds*
		(millions of long tons)	
1950–51	0 04	0 36	0 59
51–52	0 04	0 41	0 66
52–53	0 08	0 77	1 23
53–54	0 06	0 63	1 00
54–55	0 09	0 88	1 41
55–56	0 10	0 96	1 54
56–57	0 11	1 15	1 83
57–58	0 13	1 35	2 16
58–59	0 14	1 40	2 25
59–60	N A.	1 56[1]	2 50[1]
60–61	N A	1 72[1]	2 75[1]

[1] Data on fertilizer consumption were not available for 1959–60 and 1960–61 Arbitrary estimates of production were therefore made These estimates appear to be in keeping with the trend that is observed for the rest of the period.

garding improved seed are presented below as a check on the earlier assumptions regarding the response coefficient for fertilizer and as evidence of the importance of this particular technological input

Estimates concerning the acreage under improved seeds are conflicting

According to the Ford Team, "the acreage of grain crops planted to improved varieties is estimated to be only 15 to 20 percent of the total,"[33] i e, about 40 to 56 million acres This estimate was made in 1959 The Third Five Year Plan is estimating the achievements in the Second Plan puts the foodgrain area under improved seeds at 55 million acres in 1961 [34]

The NCAER report provides a much higher estimate They state that the foodgrains-producing area under improved seeds increased from 8 3 million acres in 1949–50 to 82 3 million acres in 1957–58 [35] However, the NCAER estimates are in part based on the quantity of improved seeds distributed and in part on the premiums paid to the farmers and expenditures incurred, as given by the Indian Council of Agricultural Research, Ministry of Food and Agriculture

[33] Ford Team, *op cit*, p 38

[34] The Third Five Year Plan, *op cit*, p 303

[35] Derived from the annual cropwise estimates of NCAER See NCAER, *Op cit*, p 237, Table A-63

Evidence concerning the distribution of improved seed casts doubt on the reliability of the estimates based on the quantity distributed.[36]

Furthermore, questions must be raised concerning the care taken in maintaining the quality of improved seeds An observation made by the Ford Team may be quoted here "More and more seed of improved varieties is used, yet the cultivator fails to get satisfactory yield increase because seed schemes do not provide enough good seed which is genetically pure, of high germination, free from weeds, other crops and seed-borne diseases little is known about the quality of seed planted by the farmer "[37]

These problems confirm the decision to sum the effect of improved seed and fertilizer under a single input measure and response coefficient

However, acceptance of the Third Five Year Plan estimate of acreage sown to improved seeds and the NCAER estimate of a response coefficient of a 10 percent increase in yields of foodgrains gives an impact on production in 1960–61 of slightly more than one million tons This is a small percentage of total production and even of the increment to production in the period from 1951 to 1961 It is roughly equal to the difference in estimate of response to fertilizer in 1961 when using the 10-pound response and the 16-pound response per pound of fertilizer

Estimated Increase in Production as Derived from Input Analysis

For the purposes of this study, the following function is used to describe increases in agricultural production in India

$$Y = a_1 x_1 + a_2 x_2 + a_3 x_3 + a_4 x_4$$

where Y = total production (in millions of tons)

x_1 = unirrigated land (in acres)

a_1 = response coefficient of unirrigated land and related inputs

x_2 = irrigated land

a_2 = response coefficient of irrigated land and related inputs

x_3 = labor for intensification

a_3 = response coefficient of labor

x_4 = amount of inorganic fertilizers (in tons)

a_4 = response coefficient of fertilizers and improved seeds

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[36] Inaugurating the 19th Annual Conference of the Indian Society of Agricultural Economics (December 1959), Shri H V R Iengar, Governor of the Reserve Bank, referred to the special investigation into food production programme conducted by the Reserve Bank in a few selected areas The Survey revealed that "out of eight villages surveyed in one district, only two derived any benefit at all from the seed distribution scheme, although this scheme received more attention than any other scheme, and even in these two villages, only nine out of twenty cultivators in one village and one out of twenty in another village got improved seed" As cited by M L Dantwala, *op cit*, p 37

[37] Ford Team, *op cit*, p 61

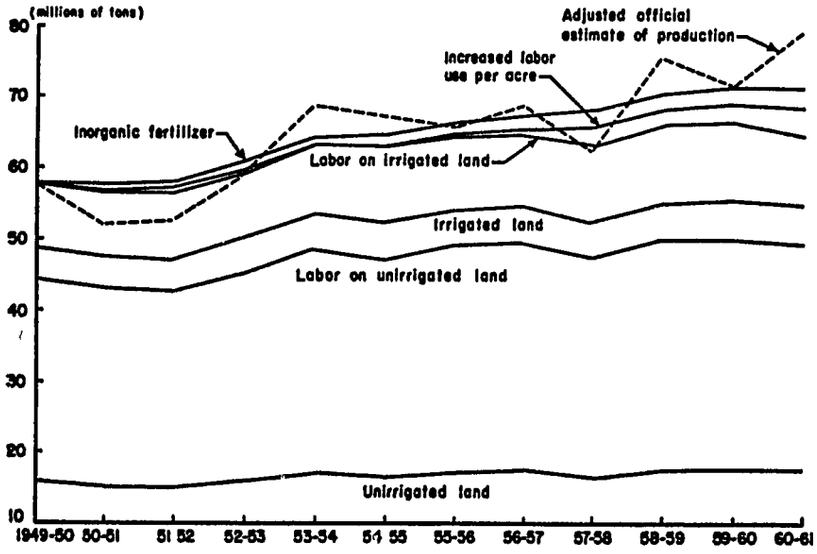
Although there is interaction among the various inputs, a linear function is used on the assumption that the coefficients chosen reflect the effect of the interaction at the expected level of the other inputs

Previous pages provide estimates of the input quantities and response coefficients Table 16 shows the calculated contribution of each of the four inputs as well as the total production of foodgrains estimated by this procedure Because of the procedures used, the estimated production in 1949–50 is the same as reported adjusted production in that year Table 17 shows cumulative increments to production for each year since 1949–50 for each input category and for total production Figure 1 shows the same data in graphic form

These estimates show the compound rate of increase in production for the period to be 2 3 percent per year This is somewhat lower than the rate estimated through the preceding methods

Of the total estimated increment to production, approximately two-thirds is accounted for by increased input of irrigated and unirrigated land The remainder is about equally split between the effect of increased labor use per acre and inorganic fertilizers The changes in technology which are reflected in the coefficient for inorganic fertilizer account for a relatively small

Figure 1 Cumulative Contributions of Various Inputs to Total Foodgrains Production, India, 1949–50 to 1960–61



proportion of the increased output in Indian agriculture in the period from 1951 to 1961 In a more general way, it can be said that two-thirds of the increase in production is due to increased acreage, and one-third to increased yields per acre

Table 16. Contribution of Various Inputs to Total Foodgrains Production, India, 1949-50 to 1960-61

Year	Unirrigated land	Irrigated land	Increased Labor per acre	Fertilizers	Total production
			(millions of long tons)		
1949-50	44 8	12 8	0 0	0 0	57 6
50-51	43 5	13 1	0 2	0 6	57 4
51-52	43 1	13 3	0 5	0 7	57 6
52-53	45 7	13 6	0 5	1 2	61 0
53-54	49 1	14 2	-0 1	1 0	64 4
54-55	47 8	15 0	0 1	1 4	64 3
55-56	49 6	14 6	0 4	1 5	66 2
56-57	50 1	14 6	0 6	1 8	67 1
57-58	48 0	15 0	2 8	2 2	68 0
58-59	50 6	15 3	2 2	2 2	70 3
59-60	50 7	15 7	2 6	2 5	71 5
60-61	49 9	16 0	3 8	2 8	72 5

Table 17 Cumulative Contribution of Various Inputs to Total Production over the Base Period, India, 1949-50 to 1960-61

Year	Unirrigated land	Irrigated land	Increased Labor per acre	Fertilizers	Total production
			(millions of long tons)		
1949-50	0 0	0 0	0 0	0 0	0 0
50-51	-1 3	0 3	0 2	0 6	-0 2
51-52	-1 6	0 5	0 5	0 6	0 0
52-53	1 0	0 8	0 5	1 2	3 5
53-54	4 3	1 4	-0 0	1 0	6 7
54-55	3 0	2 2	0 1	1 4	6 8
55-56	4 8	1 8	0 5	1 5	8 6
56-57	5 3	1 8	0 6	1 8	9 5
57-58	3 3	2 2	2 8	2 1	10 4
58-59	5 8	2.5	2 2	2 2	12 7
59-60	6 0	2 9	2 6	2 5	13 9
60-61	5 2	3 2	3 8	2 7	14.9

Table 18. Alternative Estimates of Trends in Foodgrains Production, India, 1949–50 to 1960–61

Year	Adjusted official estimates of production	Trend in production from adjusted estimates	Trend in production from estimates of consumption	Trend in production from input estimates
		(millions of long tons)		
1949–50	58	54	58[a]	58[a]
50–51	52	56	59	57
51–52	53	58	60	58
52–53	59	60	62	61
53–54	69	62	63	64
54–55	67	64	65	64
55–56	66	66	67	66
56–57	69	68	68	67
57–58	62	70	70	68
58–59	74	73	72	70
59–60	75	75	73	71
60–61	79	78	75	73
Rate of increase for the period (percent)	3 4	3 4	2 5	2 3

a Assumed base

In viewing these conclusions, it is well to refer back to the assumptions that lie behind them One might choose to reject the assumption that increased labor has been applied per acre or that such labor could be productive If these assumptions are rejected, then one must either assume that production increased at a rate of less than two percent per year or that other inputs had a greater effect than indicated It is unlikely that fertilizer input or its response coefficient is greater than indicated One must then assume that yields per acre on new irrigated and unirrigated land were higher than the average of the previously cultivated land, or, one must assume that yields per acre were increased by some device other than improved seeds, inorganic fertilizers, and labor intensification What this device might be is not immediately clear Indeed, it is possible, in the light of waterlogging and related problems, that productivity of significant acreages of land has in fact declined during this period

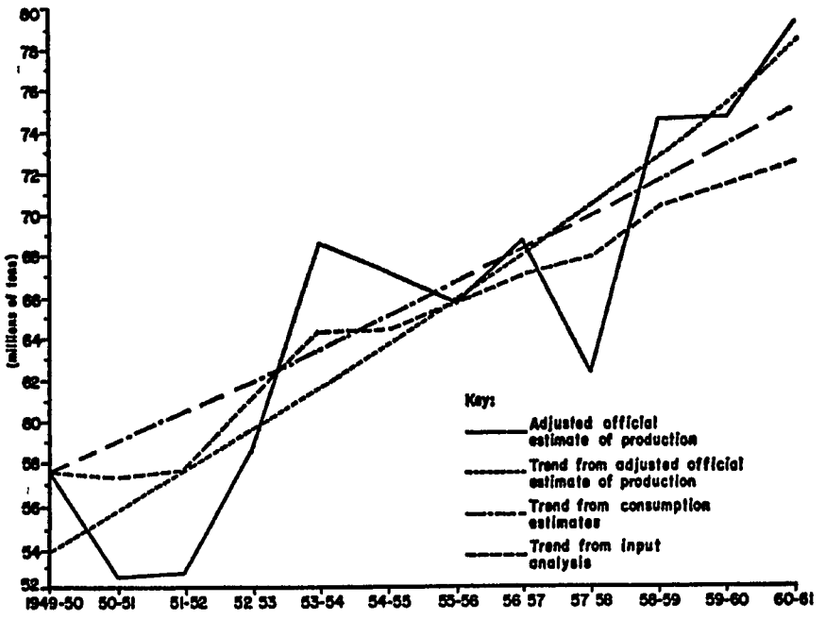
CONCLUSION

This study presents several estimates of the rate of increase in Indian foodgrains production for the period 1949–50 to 1960–61 These estimates are summarized in table 18 and in figure 2 In addition, rates of increase between groups of years and matched sets of years have been computed

The substantial effects of variation in weather greatly reduce confidence in an estimate of trend derived from official production data for the period 1951 to 1961 In addition, problems of reporting and adjustments may introduce error into official production statistics

An estimated rate of production increase of 2 5 percent per year is derived from analysis of changes in demand and consumption This is roughly the same rate of increase derived from calculating the trend between the two poor crop years of 1950–51 and 1957–58 Estimation of increased output from increased input provided a slightly lower estimate of 2 3 percent per year The assumptions made in the consumption analysis are believed to generally err on the side of an overestimate of the trend rather than an underestimate

Figure 2 Alternative Estimates of Trend in Foodgrains Production, India, 1949–50 to 1960–61



With the given assumptions, the input analysis attributed two-thirds of the production increase to increased acreage of irrigated and unirrigated land The remaining one-third is attributed to various factors increasing yields per acre, with the effect split about evenly between more labor per acre and the joint effect of inorganic fertilizer and related inputs

Each of the estimates of the rate of increase in foodgrains production is based on a number of assumptions which it would be difficult to test fully The sets of assumptions for each estimate were derived relatively independently of each other The incidence of similar estimates from the different methods of estimation shows that the various assumptions are mutually consistent Thus acceptance of a different set of assumptions in one case, suggests that the assumptions in the other approaches likewise require adjustment.

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