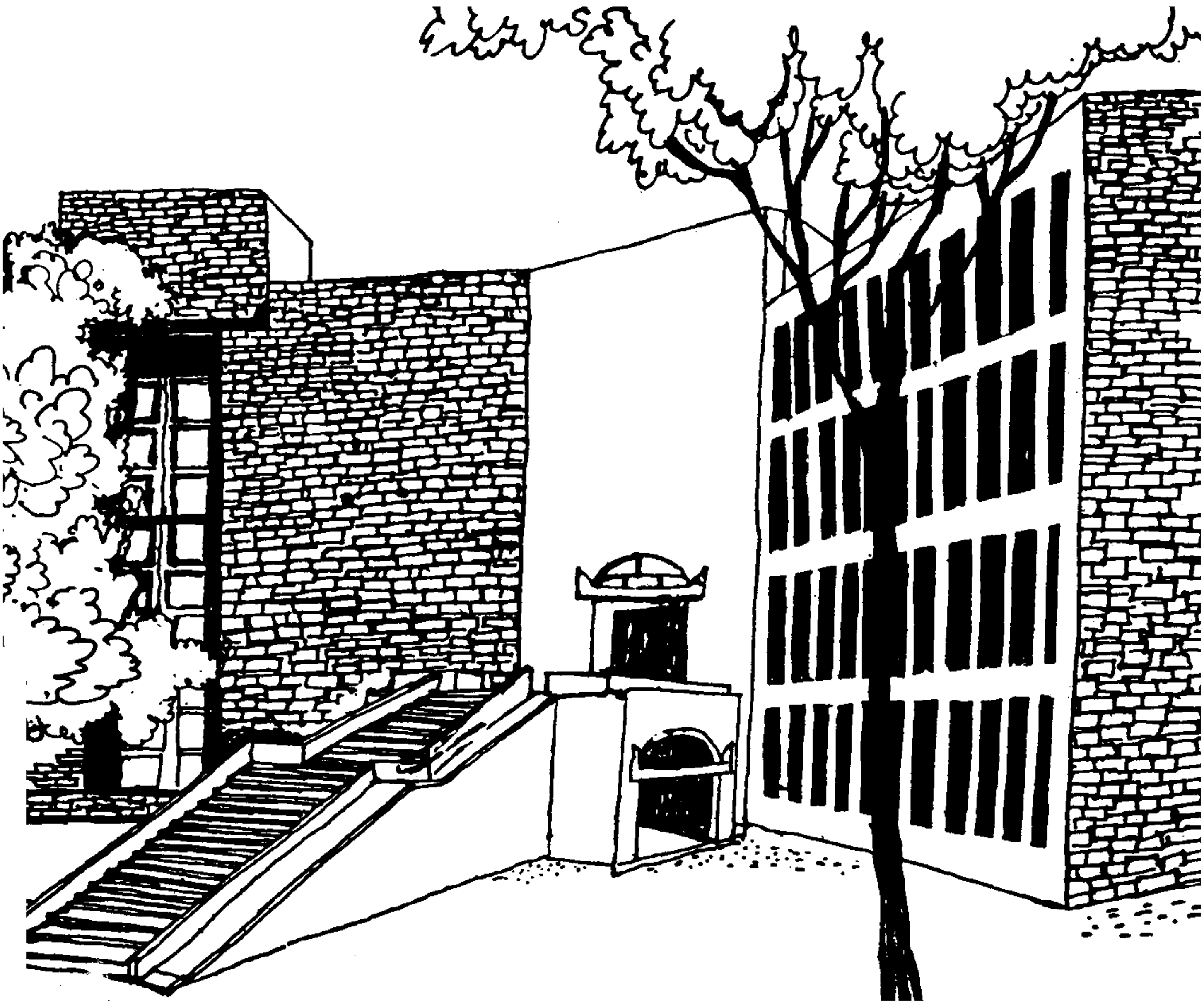
विद्याविनियोगाद्विकासः

IIM AHMEDABAD

Working Paper



IMPACTS OF ENERGY CRISIS ON INDIAN AGRICULTURE SECTOR

By

Devi D. Tewari

&

V. M. Rao

W P No. 919
February 1991

> The main objective of the working paper series of the IIMA is to help faculty members to test out their research findings at the pre-publication stage.

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380 015
INDIA

IMPACTS OF ENERGY CRISIS ON INDIAN AGRICULTURE SECTOR*

Devi D. Tewari and V.M. Rao

Authors are respectively Assistant Professor and Research Associate in the Centre for Management in Agriculture, Indian Institute of Management, Vastrapur, Ahmedabad 380 056, Gujarat, India.

*Paper to be included in the *Power and Energy Conservation Directory of India*, edited by Dr Rashmi Mayur, Astra Publishers, Bombay.

IMPACT OF ENERGY CRISIS ON INDIAN AGRICULTURAL SECTOR

Devi D. Tewari and V.M. Rao, Indian Institute of Management, Ahmedabad

INTRODUCTION

Crop production in agriculture requires large amounts of fuel, fertilizers, pesticides, etc; similarly, livestock production involves indirect use of energy inputs through feed grains. Farm machinery, which is also an important input towards agricultural production, requires indirect consumption of fuels in its manufacturing. Fuel and fertilizers, however, constitute a major proportion of total energy use in agricultural production and are also a major expense in a farmer's budget. Furthermore, energy inputs along with high yielding varieties and irrigation have been responsible for bringing green revolution in India. More specifically, fertilizers have played a significant role towards increasing agricultural output growth rates in the country. For example, in India, fertilizers are sometimes credited with up to three quarters of agricultural production as against one-half to two-thirds in the Western agricultures. Furthermore, energy use has been consistently rising in the Indian agriculture for it has to feed a large population base which is growing at the rate of about 2.2% per annum. Some indicators of energy use in Indian agriculture are presented in Table 1.

[Insert Table 1 around here]

It is important to emphasize that the increase in agricultural production in India can be ascribed to the high yielding variety seed-fertilizer-irrigation technology. An examination of trends in the past, between foodgrains production and fertilizers, between area under high yielding varieties and fertilizer use, gross irrigated area and fertilizer use in Figures 1, 2, and 3, respectively,clearly spells out that how important these inputs have been in raising agricultural production. Since these are highly energy-intensive and petro-based inputs, their use is very much influenced by the crude oil prices. Since the 1973 oil price shock when the Organization of Petroleum Exporting Countries (OPEC) unilaterally raised crude oil price, and subsequently thereafter, the prices of energy-related inputs in agricultural production have risen worldwide. It is only in the 1983 for the first time crude oil prices started falling but became volatile in the late 1980s and early 1991. It is believed that after the Gulf War, crude oil prices may start shooting up for various reasons. Some experts have forecast that crude oil price may touch 40-60 US dollar per barrel before year 2000. With this presumption in the mind, our major objectives in this paper are as follows:

1. How will the rising energy prices affect Indian agricultural sector in the medium- to long-term period, and what impacts will it have in general in the agricultural sector?

2. What impacts will rising crude oil prices have upon the country's foodgrains production in particular by year 2000?

3. What implictions are of the above upon the gap between foodgrains requirement and production during the decade in light of a population

growth at about 2.2% per annum?

4. Finally, what policy initiatives can be taken to thwart or deflect the crisis?

[Insert Figures 1, 2, and 3 around here]

In the next section, we discuss how rising crude oil prices would affect Indian agriculture sector in general in the medium- to long-run period and what kind of impacts can be seen. This is is followed by the specific impacts on foodgrains production and foodgap in particular. Conclusions and policy implications are discussed at the end.

ENERGY-PRICE IMPACTS ON AGRICULTURE

Rising crude oil prices are translated in terms of increased prices of energy-related inputs in agriculture which, in turn, affect agricultural production. There are three ways by which the agricultural sector is influenced by rising energy prices:

1. Farmers (farm managers) pay more for energy related inputs such as fuel, fertilizers, farm chemicals, farm machinery etc., causing an increased cost of agricultural production hence lowering the net farm income.

2. Farmers pay more for transporting their produce from the farm gate to the terminal point or accept lower prices from middlemen since, in the long run, increased energy cost in transportation are passed on to

producers.

3. Rising energy prices add to the general inflation in the country which in turn is fed into agricultural sector through an increase in prices of non-energy inputs as well.

Rising energy prices can have several types of energy-price impacts. Basically they can be classified into two categories: (1) environmental or non-economic impacts, and (2) economic impacts.

Environmental Impacts

Environmental or non-economic impacts refer to changes in the quality of environment as a result of changing energy-use due to increasing energy prices. It is believed that, with a decrease in energy consumption, the pollution level may be reduced due to decreased consumption of fertilizers and fuels at the farm level. However, what will be the impact on soil erosion cannot be said a priori; to a great extent it depends upon the farmers response towards change in the crop-mix. Crops like soybean are better protector of soil than maize. In general, less energy-intensive crops are less soil-erosive.

Economic Impacts

Economic impacts of rising energy prices can be classified into three categories: (1) price and production or demand related changes; (2) supply-characteristics related changes; and (3)technology related changes.

Since, energy is a major expenditure in the total variable cost of production, rising energy prices will be translated into the increased cost of agricultural production. This has two effects: one, the level of production and growth in production will be diminished; two, prices of agricultural produce will rise which will ultimately cause a general rise in the prices of food products followed by that in non-food products as well. Rising food prices will be however more unpleasent to urban dwellers than villagers but it will certainly enhance the rate of falling people below the poverty line. The aftermath will not stop here, rather will have far-reaching repercussions in the whole economy as agriculture contributes about 35-40% of the real gross domestic product generated in the country.

As said before, increased energy prices will exert upward pressure on agricultural product prices, and on the costs of production and transportation. Various studies in the past have reported that rising energy prices reduce net farm income significantly (Tewari 1990). The Indian case should not prove an exception to this as we believe. The ultimate effect of this is the reduced purchasing power of the agriculture sector which will have implications for industries integrated to agriculture through backward and forward linkages. Industries in backward linkage are those which supply inputs to agriculture sector such as seed, fertilizer, etc.; they will experience a general decline in demand for their products. Similarly industries in the forward linkage, in particular the agro-processing industries, will have to buy raw material inputs at higher prices, causing an increase in their cost of production. All this will be eventually passed on to consumers.

The supply-characteristics related changes will occur at farm level in terms of changes in the patterns of acreage, energy and other inputs uses, cropping practices, etc. Energy consumption will decline which will have repercussion on the supply of food in the economy. For example, based upon the crop-response ratio, a one million tonne reduction in fertilizer consumption is likely to reduce food production by 10 million tonnes. Irrigated agriculture will also suffer setback in particular where diesel pumps are major source of irrigation-supply on farms.

Technology related changes may be seen in terms of energy conservation measures taken on farms and elsewhere in the agricultural economy. Adoption of energy-saving technologies will be the choice of producers but will be constrained by supplies of such technologies. Research and development on energy conservation technology will play an important role and hence would require new investment.

In the Western countries, conservation tillage has come as a major energy-saving technology. For example, in the US, about one-third of croplands is under some kind of conservation or reduced tillage practices. The economic feasibility of reduced tillage is possible when other weed controlling mechanisms, such as application of pesticides, are cheaper. In the Indian situation, this technology may be partially successful, in particular on semi- and fully-mechanized farms, by adopting minimum-tillage practices if know-how and show-how of the same is arranged through proper extension works.

IMPACTS ON FOODGRAINS PRODUCTION

Estimating the different impacts of energy crisis as described above requires a more complicated modelling (Tewari and Rao 1989). We, however, have tried to make some projections by employing the following six-equation model of Indian foodgrain sector; of the six equations, the first three are behavioral relations and are estimated using systems method, using 1967-88 data. The estimated model is presented in Table 2.

Table 2: The Estimated Foodgrains Sector Model of India

1. Foodgrains Production equation

$$\ln(FGPD) = \underset{(11.68)}{3.34} + \underset{(2.82)}{0.1313^{*}} \ln(FERT) + \underset{(2.80)}{0.3867^{*}} \ln\left(\frac{HYVA}{GIA}\right)$$

N = 1967-88 $\bar{R}^2 = 0.85$ D.W = 1.5972, F = 58.6

2. Fertilizer Consumption Equation

$$\ln(FERT) = \underset{(9.49)}{15.39} - \underset{(5.71)}{9.1241^{**}} \ln\left(\frac{PF}{PA}\right) + \underset{(9.54)}{2.1741^{**}} \ln\left(\frac{HYVA}{GIA}\right)$$

N = 1967 - 88 $\bar{R}^2 = 0.85$ D.W = 0.6914^{b} F = 61.7

3. Fertilizer-Crude Oil Price Possibility Frontier Equation

$$\ln(PF) = \underset{(56.22)}{4.48} + \underset{(9.42)}{0.3031^{**}} \ln PC$$

N = 1967-88 $\bar{R}^2 = 0.80$ D.W = 0.8257^{b} F = 84.5

4. Foodgrain Requirement Identity

$$FGRQ = 0.237^{***}\ POP$$

5. Population Growth Equation

$$\ln(POP) = \underset{(4436.0)}{6.20} + \underset{(207.2)}{0.022}\ (TIME)$$

N = 1967-88 $\bar{R}^2 = 0.999$ D.W. = 0.6177^{b} F = 42913.8

6. Food Gap Identity

$$FGAP = FGRQ - FGPD$$

---

* Significant at 5% level of significance

** Significant at 1% level of significance

*** Calculated on the basis of data obtained from National Commission on Agriculture (1976).

b Positive autocorrelation

The notations used in the model are as follows:

FGPD	=	Foodgrains production, million tonnes
FERT	=	Fertilizer consumption, thousand tonnes
HYVA	=	Area under high yielding varieties, million ha
GIA	=	Gross irrigated area under crops, million ha
PA	=	Wholesale all-commodity price index (1970/71 = 100)
PF	=	Wholesale fertilizer price index (1970/71 = 100)
PC	=	F.O.B. Ras Tanura crude oil price, US$/barrel
POP	=	Population, million
TIME	=	Trend (1967 = 1, ...1988 = 22)
FGRQ	=	Foodgrain requirement, million tonnes
FGAP	=	Foodgrain gap, million tonnes

The estimated model is validated and tested for both ex-post and ex-ante forcasting performance; the model is found to be representing the reality reasonably well. The validated model is then used to simulate alternative scenarios. We have chosen four scenarios as follows.

In the Baseline Scenario, we assume that energy prices do not change and remain at 1991 level throughout the decade of 1990s. The gross irrigated area and area under high yielding varieties grow at the historical trend rate of 1% per annum. We also assume that government is not making any special effort for raising the fertilizer consumption through subsidies, etc. This scenario is considered as benchmark for other scenarios in which crude oil prices are exogenously raised. In Scenario I, other things remain as they were in the baseline except that crude oil prices are raised to US$ 40 per barrel in 1991 and thereafter increased by 10% per annum. In

Scenarios II, and III, crude oil prices are raised by 20 and 30% respectively after 1991. The values of exogenous variables used for simulation are given in the Appendix A. The difference between the baseline and other scenarios would explain the impacts of rising crude oil price in relative terms.

Impacts of rising crude oil price on foodgrains production under different scenarios are shown in Figure 4. A perusal of these reveals two things. First, we do not see an immediate impact in the early 1990s but a secular decline in production occurs as we move to year 2000. The expected decline can range in between 6 to 13% from the baseline production. Second, the growth rate in foodgrain production also slows down very rapidly. For example, with crude oil price rising to US$/40 per barrel in 1991 and thereafter increasing by 10% per annum, the growth rate in foodgrain production is almost halved (Table 3). With a 20% increase in crude oil price as under Scenario II, the growth rate is reduced to mere 0.20% per annum. A 30% increase in crude oil price under Scenario III will set the worst negative growth rate in foodgrains production.

[Insert Figure 4 and Table 2 around here]

The major implication of this is the rising foodgap. It is expected that, with the present population growth rate of 2.2% per annum, we need about 248 thousand tonnes of foodgrains by year 2000. In the baseline scenario the gap between foodgrain requirements and production is expected to be about 84 million tonnes in year 2000. This gap would increase to 94 thousand tonnes under Scenario I, and about 100 thousand tonnes in Scenario II, and about 105 thousand tonnes under Scenario III. The growth rate during the 1990s in foodgap in the baseline Scenario is about 4.5% per annum, which under the rising energy price regime would increase to 5.26, 5.92 and 6.67% per annum respectively under Scenario I, II and III (Table 3).

Impacts on fertilizer consumption and foodgap under different scenarios are plotted in Figures 5 and 6. Fertilizer consumption which grew at the rate of 9.33% per annum during the baseline Scenario fell to 4.70, 1.42, and -1.60% per annum respectively under Scenario I, II, and III (Table 3). The fertilizer consumption for selected years under different scenarios is presented in Table 4. It is to note that fertilizer consumption in 1995 declines by about 30, 37, and 43% for the first, second, and third Scenarios. In year2000, the relative magnitude of decline is expected to be much more; for example, about 41% decline from the baseline in the fertilizer consumption is predicted to occur just under Scenario I.

CONCLUSIONS AND POLICY IMPLICATIONS

Risng energy prices will have several impacts on Indian agriculture. More specifically, we would observe a secular decline in both absolute level of and growth rate in foodgrains production. Although the decline in the absolute level of foodgrains production may not seem very large in the beginning of the decade, the decline in the growth rate foodgrains production is expected to be large and this will have long-term implications in terms of feeding the growing population. The repercussions will be felt in the non-agricultural sectors as well in terms of rising food and nonfood prices and an increase in the general inflation. Policymakers therefore need to keep this in the mind while formulating the Eighth and Ninth Five Year Plans. The major policy effort will be required in terms of finding the cheaper sources of energy in the country.

REFERENCE

Central Statistical Organization, *Statistical Abstract of India 1987*, Ministry of Planning, Government of India, New Delhi, 1988, p.56.

Central Statistical Organization, *Basic Statistics Relating to the Indian Economy: 1989*, Government of India, New Delhi, 1989, p.40.

Directorate of Economics and Statistics, *Agricultural Situation at a Glance*, Government of India, New Delhi, 1988.

Fertilizer Association of India, *Fertilizer Statistics 1986/87*, FAI, New Delhi, 1989, p.II-92.

International Monetory Fund, *International Financial Statistics Year Book 1990*, IMF, Washington, 1990.

National Commission on Agriculture, *Report of the National Commission on Agriculture 1976, Part III, Demand and Supply*, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1976, pp.01-18.

Srivastava, U.K. and N.T. Patel, *Pesticides Industry in India: Issues and Constraints in Its Growth*, Oxford and IBH, New Delhi, 1990, p.8.

Tewari D.D. "Energy-Price Impacts Modelling in the Agriculture Sector," *Energy Economics*, April 1990, pp.147-158.

Tewari, D.D. and V.M. Rao, "Modelling Energy Use in Indian Agriculture: A Sectoral Approach," *Vikalpa: The Journal for Decision Makers*, 14(4), 1989, pp. 29-34.

Table 1: Some Indicators of Energy Use in Indian Agriculture, 1955-87

Sl. No.	Particulars	Unit	1954/55	1966/67	1986/87	% Change between 1966/67 and 1986/87
01	Fertilizers consumption	000 Tonnes	120.90	1100.60	8738.40	694.0
02	No.of diesel pumps	000's	170.00[a]	886.00[b]	6669.00[c]	652.7
03	Pesticides consumption	000 Tonnes	N.A.	15.34	102.33[d]	567.0
04	Area under HYV	Million ha.	000.00	1.89	54.04	2759.0
05	Food Production	Million Tonnes	068.03	74.23	144.07	94.1

N.A. Not available

a Data related to 1956 for oil engine pumps and electric pumps

b Data related to 1966.

c Data related to 1982.

d Data related to 1985/86

Source: (a) Srivastava, U.K. and N.T. Patel (1990)

(b) Directorate of Economics and Statistics (1988)

(c) Central Statistical Organization (1988)

Table 3: Impacts of Rising Crude Oil Prices on Growth Rates of Foodgrains Production, Fertilizer Consumption, and Foodgap

Sl. No.	Particulars	Baseline	Scenario I	Scenario II	Scenario III
01.	Foodgrains Production	1.22	0.62 (-49.1)[a]	0.19 (89.9)	-2.10 (272.1)
02.	Fertilizer Consumption	9.33	4.70 (-49.6)[a]	1.42 (89.7)	-1.60(-117.1)
03.	Foodgap	4.44	5.26 (18.5)	5.92 (33.3)	6.67 (50.22)

[a] Figures in parenthesis are percent change from the baseline.

Table 4: Impacts of Rising Crude Oil Price on Fertilizer Consumptions, India

Selected Years	Baseline	Scenarios I	Scenarios II	Scenarios III
		............000 Tonnes	....	
1995	229	162 (-29.3)[a]	145 (-36.7)	131 (-42.8)
2000	347	206 (-40.6)	157 (-54.8)	122 (-64.8)

[a] Figures in parentheses are percent change from the baseline.

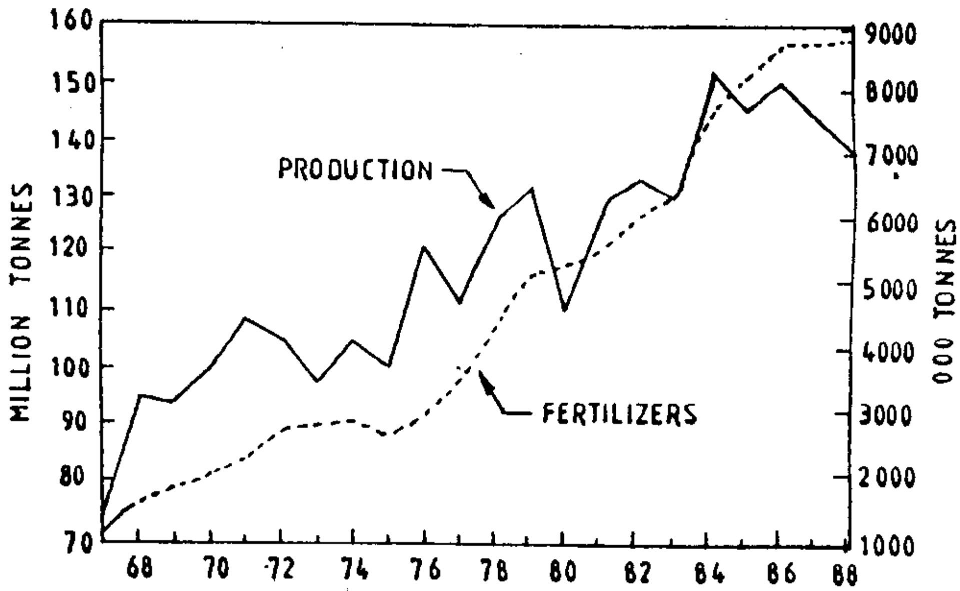


Figure 1: Trends in Foodgrain Production and Fertilizer Use in India, 1967-88

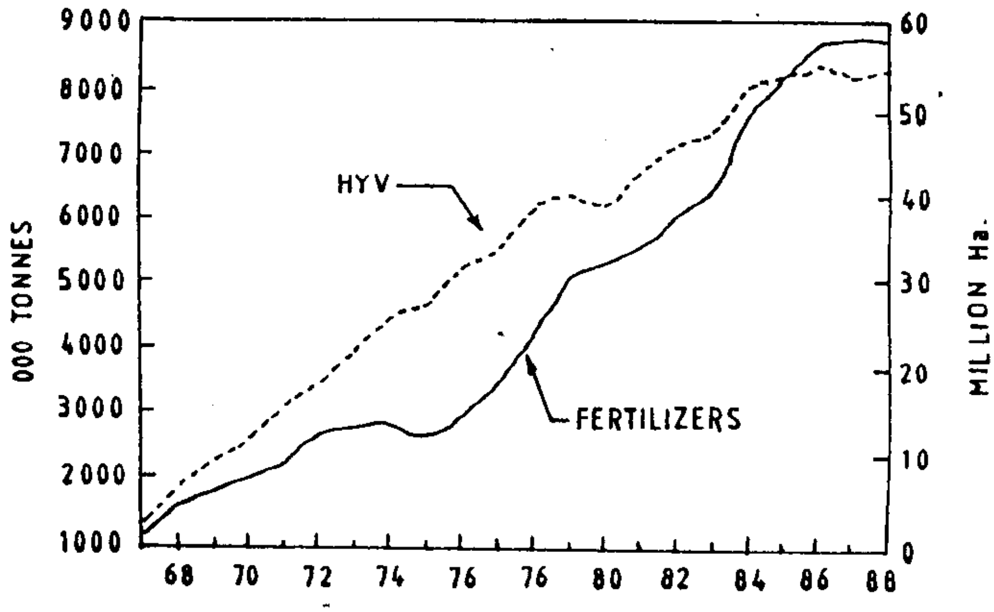


Figure 2: Trends in Area Under High Yielding Varieties and Fertilizer Use in India, 1967-88

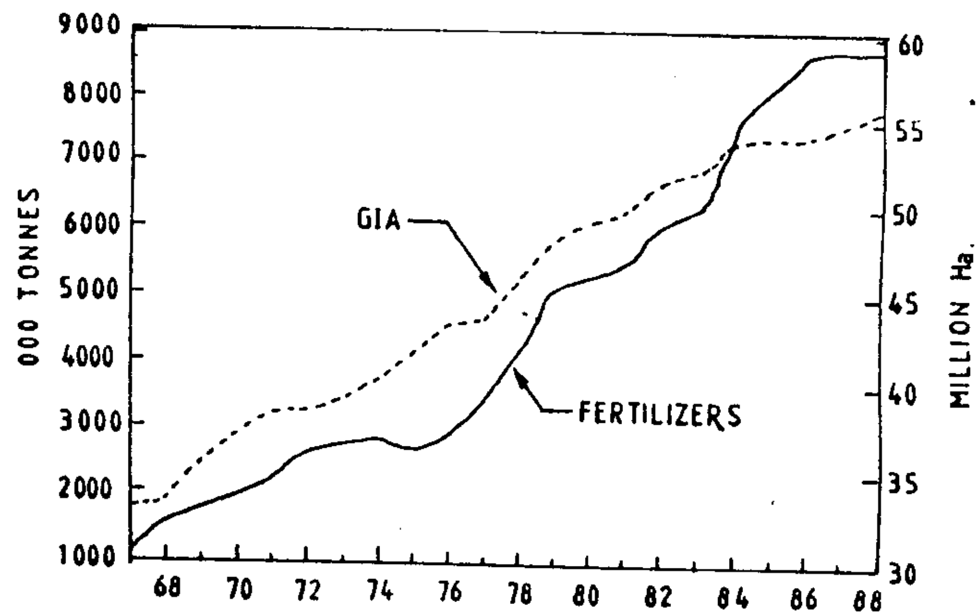


Figure 3: Trends in Gross Irrigated Area and Fertilizer Use in India, 1967-88

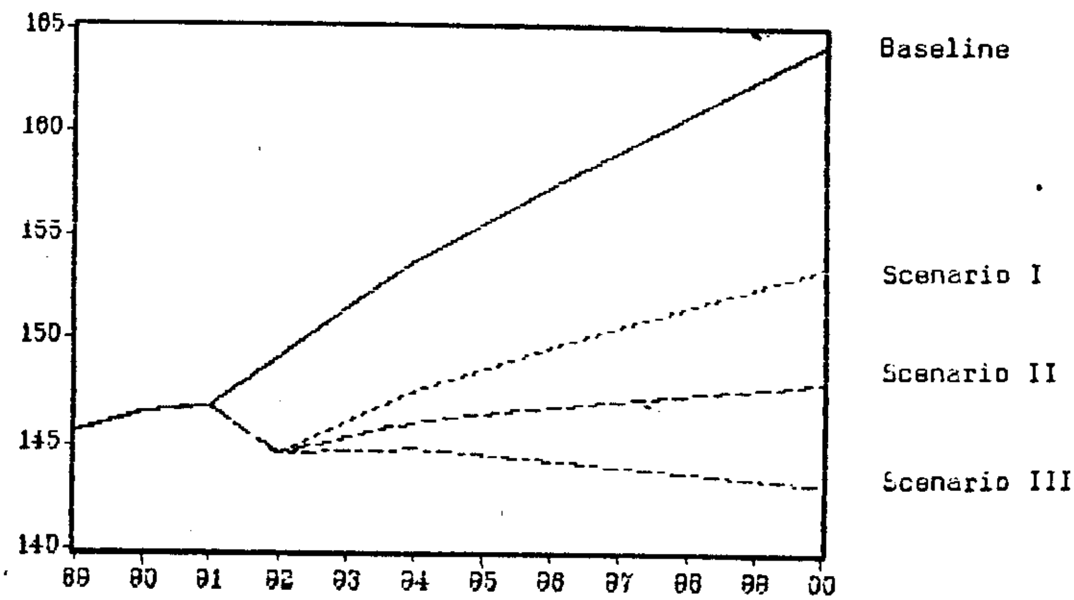


Figure 4: Impacts of Rising Crude Oil Prices on Indian Foodgrains Production under Different Scenarios, 1991-2000

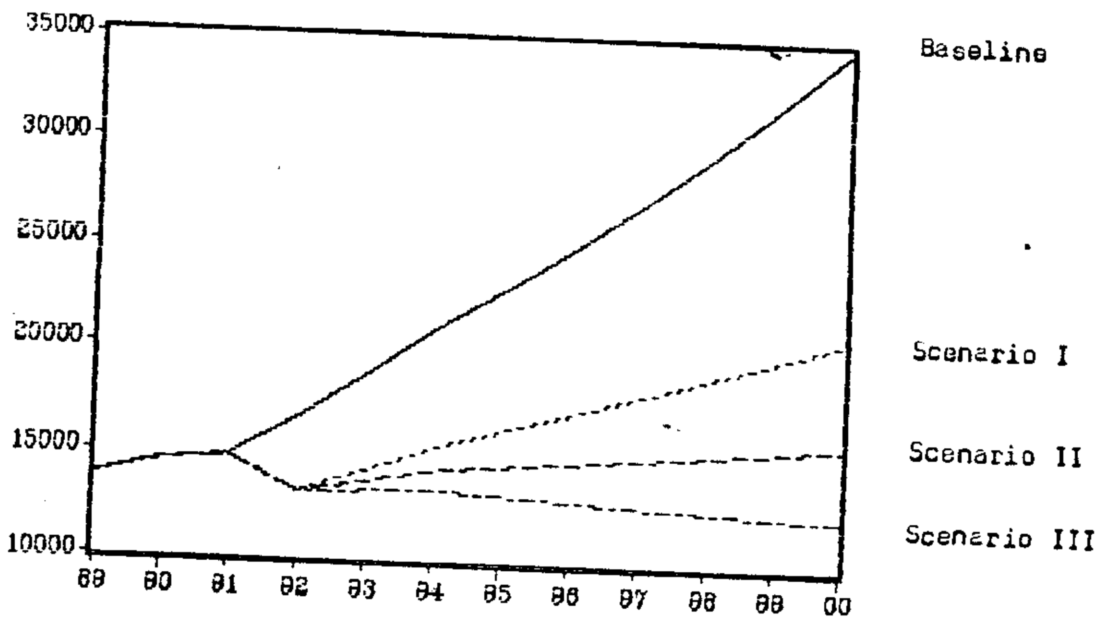


Figure 5: Impacts of Rising Crude Oil Prices on Indian Fertilizer Consumption under Different Scenarios, 1991-2000

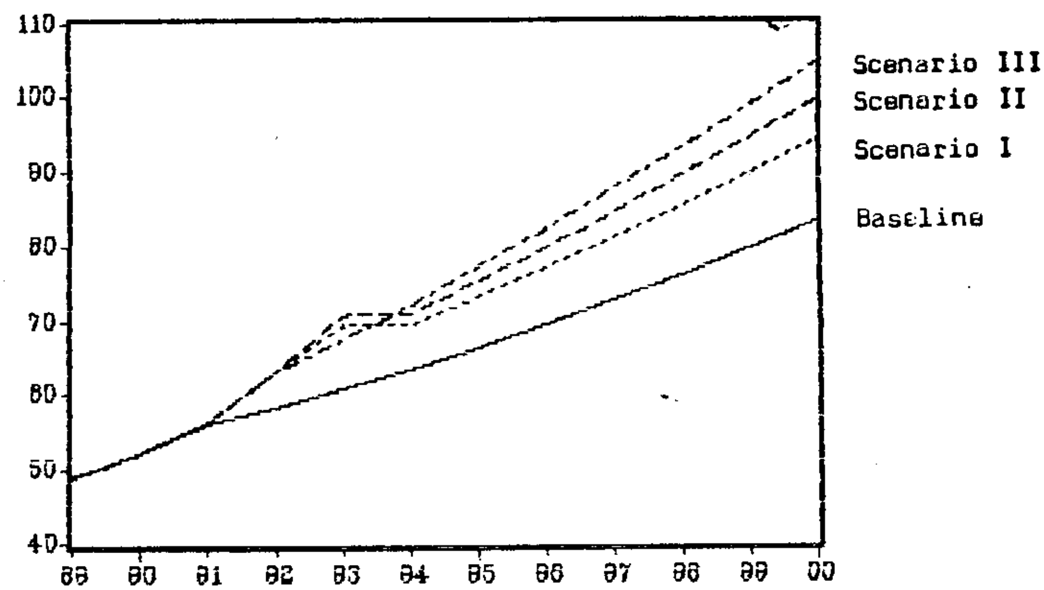


Figure 6: Impacts of Rising Crude Oil Prices on Foodgap under Different Scenarios, 1991-2000

Appendix A

Table A.1: Values of Crude Oil Price Used under Different Scenarios, FOB Ras Tanura, 1989-2000

Year	Baseline	Scenario I	Scenario II	Scenario III
1989	17.18	17.18	17.18	17.18
1990	19.23	19.23	19.23	19.23
1991	23.11	23.11	23.11	23.11
1992	23.11	40.00	40.00	40.00
1993	23.11	44.00	48.00	52.00
1994	23.11	48.40	57.60	67.60
1995	23.11	53.20	69.12	87.88
1996	23.11	58.50	82.94	114.24
1997	23.11	64.40	99.53	148.51
1998	23.11	70.80	119.43	193.06
1999	23.11	77.90	143.32	250.98
2000	23.11	85.70	171.98	326.27

Table A.2: Values of Gross Irrigated Area, High Yielding Varieties Area, and All Commodities Price Index Used under Different Scenarios, 1989-2000

Year	GIA	HYV	ACPI
1989	56.28	55.55	435.30
1990	56.84	56.11	470.10
1991	57.41	56.67	507.70
1992	57.98	57.24	558.50
1993	58.56	57.81	614.30
1994	59.19	58.39	675.70
1995	59.74	58.97	729.80
1996	60.34	59.56	788.20
1997	60.94	60.16	851.20
1998	61.55	60.76	919.30
1999	62.17	61.36	992.80
2000	62.79	61.97	1072.20